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Note outfit being driven over ramp into tank.

MOBILITY AND SPEED

In a Rotinoff contract at Dartford which has just been concluded with outstanding success, more than 1400 shell piles have been driven with the Rotinoff mobile unit.

The piles were required to be driven within existing sewage precipitation tanks—59 piles in each of 24 tanks—the mobile unit was taken in and out of the tanks over a temporary ramp, as shown in the photograph. Including all time spent in moving from one tank to the other, as many as 60 piles a week were driven by the unit, varying in length from 17 ft. 6 in. to 37 ft. 6 in. This variation in length with ordinary pre-cast piling would of course have involved costly wastage. The mobile unit is extremely adaptable, and piles may be driven at a rake.

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A booklet giving tabulated information relating to a large number of varied Rotinoff contracts will be sent on request to:

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Northampton General Hospital.
East Suffolk & Ipswich Hospital, Ipswich.
Oster House Institution, St. Albans.
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A Seven-Day Journal

The Royal Fleet Review.

ON Tuesday last, July 16th, His Majesty the King reviewed his naval and mercantile fleets at Spithead. The weather was ideal for the sea pageantry of a Jubilee Review. The ships, which were fully dressed and manned, were assembled in eight long lines, which stretched from Horse Sand Fort, off Portsmouth, to Lee-on-Solent pier. A freshening breeze prevented all from hearing the Royal Salute of 21 guns which heralded the approach of the Royal Yacht, but all admired the graceful lines of the "Victoria and Albert" as she slowly steamed down the lines, led by the Trinity House vessel "Patricia" and escorted by the new Admiralty yacht "Enchantress" and attendant sloops, followed by the Admiralty guest ships. Equally impressive was the fly past of the Fleet Air Arm squadrons, which dipped gracefully in salute of the Royal Yacht on her homeward voyage. From ten o'clock in the evening until midnight all the King's ships were illuminated, and there was a display of searchlights, rockets, and flares. About 300 members and guests of the Institution of Naval Architects saw the afternoon part of the Review from the Southern Railway Company's cross-Channel steamers "Dinard" and "Biarritz," which were anchored off Lee-on-Solent.

The Late Mr. J. P. Scott Main.

THE unusual heat of late has claimed many victims, and we are afraid that one amongst them was Mr. Scott Main, who died very suddenly on Sunday last, July 14th. Mr. Main was born in Scotland and educated at Dumfries Academy. He received his early railway training on the old Manchester, Sheffield and Lincolnshire, whence he went to the railways of the Queensland Government. He started what was to become his life's work when, on the passage of the Railway Employment (Prevention of Accidents) Act, 1900, the Board of Trade was authorised to appoint two practical railwaymen to inquire into the nine serious accidents to railway servants. Automatic couplings and either-side brakes brought conflict of opinion between the Board of Trade and the railway companies, but the Railway Employment Safety Appliances Committee, appointed on April 28th, 1906, with Mr. Main as its secretary, gradually disposed of those and many less thorny questions. In 1901 one shunter in every 264, one goods guard in every 374, and one permanent-way man in every 550 was killed. By the administration of the Act of 1900, mainly under the guidance of Mr. Main, those ratios have been raised to one in 627 for shunters, one in every 808 for goods guards, and one in 993 for permanent way men, and the ratio for all grades from one in 1173 to one in 3021. His practical locomotive experience made Mr. Main of frequent use to the inspecting officers of railways, and on Colonel Mount's promotion in 1929 to the position of Chief Inspecting Officer, Mr. Main was given the new rank of Assistant to the Chief Inspecting Officer of Railways. He was a member of the Institution of Mechanical Engineers.

The Destroyer Depot-Ship "Woolwich."

ALTHOUGH not a fighting craft, the new depôt ship for destroyers, H.M.S. "Woolwich," is a naval vessel of unusual interest. She has recently been delivered to the Admiralty by the Fairfield Shipbuilding and Engineering Company, Ltd., of Govan, Glasgow, and will shortly leave on Mediterranean service. Her length is 575ft. and her displacement 8750 tons, and her propelling machinery, consisting of 6500 s.h.p. twin-screw single reduction geared turbines, taking steam from oil-fired Yarrow boilers, is designed for a trial speed of 15 knots. The only armament carried is four 4in. anti-aircraft guns. The large workshops on the ship are laid out to deal economically and expeditiously with every repair requirement in a flotilla fleet, be it concerned with hull, propelling machinery, electrical equipment, or armament. Machine tools of the latest type have been chosen, and have contributed to the building up of a first-class repair plant. Some idea of the number and size of the machines may be gained from the fact that the motor horse-power exceeds 2000. The accommodation for officers and men provides, not only for the staff and crew of the "Woolwich," but also for additional *personnel* who may have to be accommodated on the depôt ship during the time their own units are under repair.

The Distribution of Electricity.

IN reply to a question in the House of Commons on Thursday, July 11th, as to whether the Minister of Transport proposed to institute any inquiry into the need for improving the distribution of electricity in this country, Mr. Hore-Belisha said that the matter had been closely studied by the Electricity Commissioners in the ordinary course of their duties and had engaged the attention of the Government. He recalled the small Committee under the chairmanship of Lord Weir which investigated the national problem of the supply of electrical energy and its recommendations on which the Electricity Supply Act of 1926 was based. Following upon the co-ordination of generation which has now been secured by that Act, the Government has decided, the Minister stated, to appoint Sir Harry McGowan, Sir John Snell (the Chairman of the Electricity Commissioners), and Mr. John Morison (a chartered accountant), to review the existing organisation of distribution with the following terms of reference:—"To bring under review the organisation of the distribution of electricity in Great Britain, including the control of statutory electricity companies by other companies, to advise on methods by which improvements can be effected with a view to ensuring and expediting the standardisation of systems, pressures, and methods of charge, further extending facilities (including supplies in rural areas), and reducing costs, and to make recommendations." The last annual report of the Electricity Commissioners, for the year 1933–34, shows that there are now 635 public authority and company undertakings engaged in the distribution of electricity in areas which range from 1 square mile or less up to 2000 square miles and over. Of these, 373 are local authorities, eight joint authorities and joint Boards, and 254 companies. The companies include twenty-eight power companies which have rights to supply current in bulk and for power purposes over very large areas which in many cases overlap the areas of the ordinary distribution undertakings.

Proposed Forth and Tay Bridges.

As recorded in a Journal note of March 8th, a scheme for building a road bridge across the Firth of Forth was discussed earlier in the year in Edinburgh by interested local authorities. More recently, on June 24th, a joint meeting of East of Scotland local authorities held a meeting with a view to linking up the proposed Forth and Tay bridge schemes, and a committee was appointed to explore the question, to consider all relative financial questions, to ascertain what financial contribution would be borne by the State and by the individual local authorities, and to procure as far as possible statistics as to traffic requirements. At a private meeting of the committee on Wednesday, July 10th, under the chairmanship of the Earl of Elgin, the following conclusions were reached:—"That the Ministry of Transport or interested local authorities be asked to take a census at suitable points of traffic likely to use both or either of the bridges; that a statement be prepared showing possible contributions from interested local authorities, divided into three groups, indicating a limited rate for each towards the capital cost of both bridges, leaving the balance to be met from grant and from tolls." A further meeting of the joint sub-committee is to be held in September.

Scientific Management.

IN the unavoidable absence of the Prince of Wales, the Sixth International Congress for Scientific Management was opened by the Duke of Kent in the Central Hall, Westminster, on Monday last. It is understood that nearly 2000 delegates are attending the conference and that thirty-four countries, including the British Commonwealth as a single unit, are represented. In his speech the Duke of Kent expressed a hope that in discussing questions of rationalisation, planning, and systems, the conference would not overlook that behind all its work was the human being, whose welfare, ultimately, was bound to be the main issue. The presence of responsible experts from all over the world was significant of the will to avoid the repetition of old mistakes and of a faith in the possibility of finding solutions to old problems. "It was," said the Duke, "only by pooling their knowledge and ideas that they could hope to surmount the difficulties of the future, and in their factories, farms, and homes be ready to meet with confidence the changes and challenges of a developing civilisation." Sir George Beharrell, Chairman of the Congress, when welcoming the Duke of Kent, expressed the pleasure given to the Congress by the promise of the Prince of Wales to attend the concluding meeting on Thursday.

Wireless Communication for Afghanistan.

FIVE wireless stations are to be erected in the most important centres in Afghanistan for internal and external communication. The most powerful will be at Kabul, where a short-wave transmitter suitable for telegraphy and telephony and two receivers are to be installed. With an output of 5–6 kW when working on telegraphy and 3½–4½ kW on telephony to the aerial feeders, the transmitter will cover a wave range of 15–80 m. A flexible valve drive with a stability of 1 in 20,000 is to be provided, and owing to its precise calibration the use of a wave meter for setting the transmitter to the required wavelength will be unnecessary. The station will communicate with the principal capitals of Western Europe, with Moscow, Tokio, Shanghai, and New York by means of directional aerials, and with Rio de Janeiro, Cape Town, and Melbourne with omni-directional aerials. For providing a better signal-to-noise ratio and to reduce the effects of atmospherics directional aerials will be used for reception. The receiving and transmitting sites will be separated and will be about 10 miles from the city of Kabul, where the central telegraph office for the control of the wireless stations will be situated. The other four stations for internal communication will be at Maimana, Khanabad, Khost, and Diyazungi, where general short-wave long-distance quartz crystal controlled transmitters will be employed. On continuous wave telegraphy each transmitter will be rated at 500 watts, and 250 watts on telephony. These transmitters and all the other equipment associated with the scheme are being supplied by the Marconi Company.

Tin-plate Manufacture in Lincolnshire.

THE transference of an important part of the tin-plate production of the country from South Wales to Lincolnshire has been discussed as an abstract possibility for a year or two, but it is only natural that the announcement in that connection by Sir William Firth, chairman of Richard Thomas and Co., Ltd.—the most important tin-plate firm in South Wales—should create something like consternation in that area. Sir William explained that as a result of the reorganisation of the company it had liquid cash resources of £1,090,000, and it was proposed to expend that money on the erection at the Redbourn Works of a modern strip mill capable of producing 150,000 tons of tin-plates and sheets per annum of the highest grade, at a cost much below that obtainable at any other works at present in this country and at a minimum saving of £200,000 a year. The chairman did not give details of the new plant, but it is understood that the present intention is that it shall be working in eighteen months and that it shall comprise one of the newest continuous American strip mills, some of which can roll strip up to 60in. wide. No doubt the progress which has been made in America in the production of tin-plates upon these mills has forced Richard Thomas and Co., Ltd., to initiate their new undertaking. The Redbourn property offers a particularly favourable site for such a plant; it has appropriate buildings and space and a supply of cheap ore suitable for the production of the necessary steel. The hope is expressed that improving world trade conditions will make it unnecessary to close plant in South Wales, but the company's estimate of saving was based on the supposition that the demand will not increase, and some Welsh mills would have to be closed down.

The Late Captain Harry James Spiers.

CAPTAIN HARRY JAMES SPIERS, who died suddenly at Park Gates Hotel, Eastbourne, on the 9th inst., was very well known in marine engineering circles. He will be remembered by his numerous friends in this country as the manager for many years of the works of Messrs. Humphreys, Tennant and Co., of Deptford, whom he left in 1908 to take over the management of the shipyards and engineering works of La Societad Espanola de Construccion Naval in Spain, where a large number of warships for the Spanish Navy were constructed under his direction. He retired in 1925. Mr. Spiers held a commission in the Royal Naval Reserve, and had, amongst other decorations, the R.D. and the Grand Cross of Naval Merit of Spain. He was a member of the Institute of Naval Architects and of the Institute of Marine Engineers.

Palmers Hebburn.

IN a Journal note of April 12th we recorded the purchase by Vickers-Armstrongs, Ltd., of the ship-repairing and dry-dock interests of the Palmers Hebburn Company, Ltd., and we then referred to possible improvements in equipment. In an official statement issued at the end of last week the names of the members of the reconstituted board are given. Sir Charles Craven is chairman, and Colonel D. R. MacDonald, Mr. A. J. Hendin, Commander E. R. Micklem, Mr. W. Leslie Runciman, and Mr. E. L. Champness are directors. The dockside fitting shop at Hebburn is being equipped for large oil and steam engine repairs. A new repairing jetty giving a continuous wharf length of 700ft. is to be constructed, and will be served by two Babcock 10-ton cranes and a 20-ton dockside crane. Improvements are being made to the dock pumping plant, which is being electrified, and a full range of oil storage and separating tanks for oil tankers is being installed. The new dock is the largest privately owned dock between Rosyth and Southampton, and already a large number of ship and engine repairs have been booked. In August a new foundry, to be called the Vickers-Armstrongs Hebburn Foundry, is to be opened, and following general reconditioning work, the installation of a new sand-blasting plant, and other alterations, will be employed in the production of castings for Vickers-Armstrongs' Elswick works.

The Differential Analyser.

No. I.

THE machine known as the differential analyser, an example of which was recently installed in the Physics Department at Manchester University, is a device for dealing mechanically with complex mathematical expressions. Its interest is not however confined to mathematicians and physicists. Engineers with little or no mathematical knowledge will find in certain of its constructional details several features that will greatly appeal to their mechanical instincts.

In order to make the scope and object of the machine reasonably clear it is necessary to explain that, contrary to a common belief, mathematics is an imperfectly developed science and that in the course of its application to practical problems expressions are frequently encountered against which its ordinary processes break down or which can be handled only with very great labour.

A simple instance of an intractable expression occurs in the problem of finding the circumference of an ellipse. In an attempt to find a finite general expression, corresponding to $2\pi r$ for the circle, an expression, known as an elliptic integral, is encountered. This expression, of the form,

$$S = a \int \sqrt{(1 - k^2 \sin^2 \theta)}\, d\theta \quad . \quad . \quad . \quad (1)$$

cannot be integrated except by expanding the right-hand side as an infinite series. As a result there is no general expression for the circumference of an ellipse. The best we can do is to write it as $K\pi(a+b)$, where a and b are the semi-axes and K is a numerical coefficient representing the sum of an infinite series. The value of K varies with a and b and, given the semi-axes, may be calculated or obtained from tables which have been compiled.*

A second type of intractable elliptic integral is encountered in the study of the simple pendulum. The familiar expression for the periodic time, $T = 2\pi\sqrt{l/g}$, is an approximation applicable without serious error only if the amplitude of swing is very small. The true period varies with the amplitude and is given by

$$T = 4\sqrt{\frac{l}{g}} \int \frac{d\theta}{\sqrt{(1 - k^2 \sin^2 \theta)}} \quad . \quad . \quad (2)$$

which, as before, cannot be integrated except by expanding the right-hand side as an infinite series. The true period of vibration of a simple pendulum is therefore given by $T = R\, 2\pi\sqrt{l/g}$, where R is a numerical coefficient representing the sum of an infinite series. The value of R depends upon the amplitude and, given the amplitude, may be calculated or obtained from published tables.

Another example of intractability occurs in the study of damped vibrations. The ordinary differential equation for a damped vibration, namely,

$$\ddot{x} + A\dot{x} + Bx = 0 \quad . \quad . \quad . \quad . \quad . \quad (3)$$

assumes, as the second term shows, that the damping resistance is proportional to the first power of the vibrational velocity, $\dot{x}$. Experiment however shows that except at very low velocities the resistance is generally proportional to the square of the velocity. The corresponding differential equation is therefore

$$\ddot{x} + A(\dot{x})^2 + Bx = 0 \quad . \quad . \quad . \quad . \quad (4)$$

In the first form (3) the equation can readily be solved, that is to say, we can derive from it an expression giving the displacement x of the vibrating body at any instant, t. The second equation (4) has so far resisted solution except by a process analogous to expansion in series.

There are many other expressions which are intractable for fundamental mathematical reasons. In addition there are many expressions which although mathematically tractable, involve an inordinate amount of labour in their numerical evaluation particularly if, as is frequently the case, their numerical values are required at a considerable number of points corresponding to different values of the independent variable. Thirdly, there are many functions, such as experimentally determined curves, which are intractable to mathematical analysis because of their irregularity or discontinuity, that is to say, because of the impossibility of expressing their form by an algebraic relationship.

The position, partially at least, is summarised graphically in Fig. 1. Curve A represents one of which the equation, $y = f(x)$, is known and is integrable. In this case from the equation to the curve we can derive a general finite expression for the magnitude of the area under it and bounded by the ordinates O Y and $a\,a$ or any other pair of ordinates. Filling into this expression the values of the constants involved and the figures defining the limiting ordinates, we may calculate the size of the area in square inches or other units. Curve B is intended to represent one the equation to which, $y = F(x)$, is known but is intractable to integration. We cannot in this case find a general finite expression for the area under it and have to be content, at the most, with a figure obtained by summing as many terms of an infinite series as we may consider necessary for accuracy. Curve C is an irregular curve without an equation and therefore, because of its geometrical form, not amenable to mathematical treatment.

In all three cases, it is to be noted, the area under the curve might be measured by means of a planimeter or other mechanical integrating device. In other words the possibility of mechanical integration

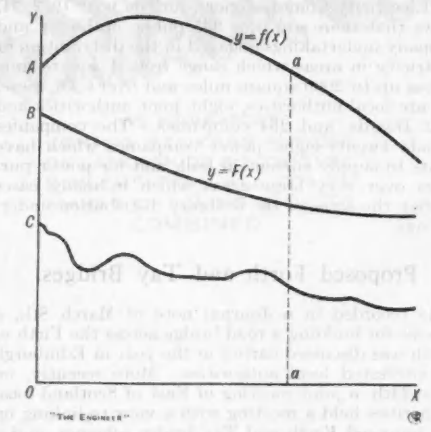

FIG. 1

does not depend upon the form of the curve being expressible by an equation or upon a knowledge of that equation or upon its amenability to mathematical integration. While mechanical integration possesses this very valuable characteristic it suffers from the disadvantage that it yields a result which is a pure number and not a mathematical expression. For instance in the case of curve A mechanical integration would give us the answer to be obtained by filling the appropriate numerical values into the general expression for the area yielded by mathematical integration. It would not however disclose in any way the form of that general expression. Similarly it would not reveal the mathematically unattainable general expression for the area under the intractable curve B or the irregular curve C. The results of mechanical integration, being numbers and not mathematical expressions, are not available for further mathematical analysis. They may, however, be available for subsequent arithmetical analysis or for additional mechanical treatment.

From these preliminary remarks some idea of the scope and object of the differential analyser will have

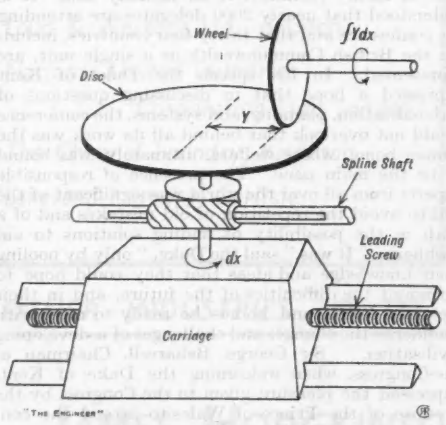

FIG. 2—MECHANICAL INTEGRATOR

been obtained. One additional point should be noted. The machine is something more than a mechanically operated recording planimeter. The essence of the planimeter lies in the application of its tracing point to a curve or, in general, the manipulation of the device in such a way that some point in it follows a defined path representing the curve presented for study. For example the equation

$$y = a\sqrt{(1 - k^2 \sin^2 \theta)} \quad . \quad . \quad . \quad . \quad (5)$$

represents a curve which, given the values of the constants a and k, we can readily plot. The application of the planimeter to this curve would give the answer which would be yielded if it were possible to integrate and evaluate the elliptic expression quoted at (1) above. Similarly equation (2) might be handled mechanically by plotting the curve involved and applying a planimeter to it. Expressions such as (3) and (4) cannot however be handled in the same manner. They do not define, as they stand, any curve which we can plot as our starting ground. They merely tell us that a certain relationship exists between the acceleration, velocity and displacement of a moving body and from them we are required to deduce or draw a curve showing the position of the body at any instant. Since there is no initial curve upon which to operate, the planimeter, as ordinarily used, is not applicable in such cases. The differential analyser is distinguished from the common planimeter by the fact that it can deal with equations of the form (3) or (4) as readily, or almost as readily, as equations of the form (1) or (2).

The basis of the differential analyser consists of a simple mechanical integrating device of the form sketched in Fig. 2. A hardened and polished steel disc is mounted horizontally on a carriage which slides along a pair of horizontal guides under the control of a leading screw. The disc can rotate on its axis, motion for this purpose being communicated to it through a worm wheel, worm and spline shaft—actually, although not shown, through two worms and shafts one on each side of the worm wheel. Resting edgewise on the disc is a hardened steel wheel mounted to rotate on a horizontal axis which is directed radially towards the axis of the disc and is parallel with the carriage guides. The distance Y at which the wheel lies from the centre of the disc is variable according to the displacement communicated to the carriage by the leading screw. The action and accuracy of the device depend upon the assumption that the rotary movement of the disc is communicated to the wheel without slip and upon the further assumption that no rotary movement is communicated to the wheel by the sliding movement of the disc. These assumptions are analogous to those made in connection with the theory of the planimeter. Their truth will depend upon the thickness of the wheel edge, the pressure and coefficient of friction between the wheel and disc, the external torque resisting the rotation of the wheel shaft and other factors.

If the distance Y be regarded as fixed while the disc rotates through a small angle $\delta\theta$ then, in the absence of slip, the wheel will turn through a small angle $\delta\varphi$ given by $(Y/r)\,\delta\theta$ where r is the radius of the wheel. The distance Y may now be changed and thereafter the disc given a second small angular

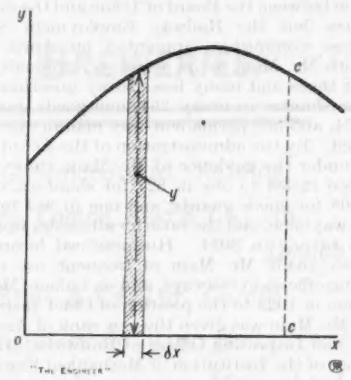

FIG. 3

displacement causing a second small movement of the wheel. If the steps are made extremely small the result, so far as the movement of the wheel is concerned, will be indistinguishable from that which would be produced by allowing the disc to rotate and slide simultaneously instead of separately. Since the sliding movement of the disc is by assumption without effect on the rotary movement of the wheel the total angular movement of the wheel after a time will be representable by the sum of a large number of terms of the form $(Y/r)\,\delta\theta$.

Let it be supposed that the distance Y is governed through the leading screw in such a way that it is at all times proportional to the ordinate y of a given curve and that the angular displacement $\delta\theta$ of the disc is proportional to δx representing an increment in the abscissa of the curve. Then each small term $(Y/r)\,\delta\theta$, since r is constant, will be proportional to the product $y \cdot \delta x$ that is to the elemental area cross hatched in Fig. 3. The total rotation of the wheel in a given time will therefore be proportional to the total area under the curve up to the boundary ordinate $c\,c$ reached at the end of the period. Expressed mathematically the total rotation of the wheel will be proportional to $\int y\,dx$.

There may appear to be some indefiniteness about the small increment of the abscissa which is marked δx in Fig. 3. We will therefore clear it up before proceeding farther. The machine has an "input table" on which the curve to be integrated is laid down as shown in the diagram, Fig. 4. A "bridge" carrying a pointer spans this table. The bridge is driven across the table by power. The pointer is moved along the bridge by a hand drive which is operated to make the pointer follow the curve as the bridge moves across the table. The shaft by which the pointer is moved along the bridge is coupled up

* Since π is itself in reality the sum of an infinite series it might be thought that we are no worse off in the case of the ellipse than in the case of the circle. The fundamental difference will be brought home by a comparison of the two problems (*a*) what is the diameter of a circle of given circumference? (*b*) what are the semi-axes or what is the sum of the semi-axes of an ellipse of given circumference?

to the leading screw indicated in Fig. 2 in such a way that movement of the pointer produces a proportional increase or decrease in the distance Y. The bridge power drive is coupled up to the spline shaft in such a way that the bridge movement is always in unison with the rotation of the disc. It is not essential to the action of the machine that the speed of the bridge and of the disc should be constant. They must, however, at all times preserve a constant proportionality. If this relationship is fulfilled then any small increment δx in the abscissa will in the

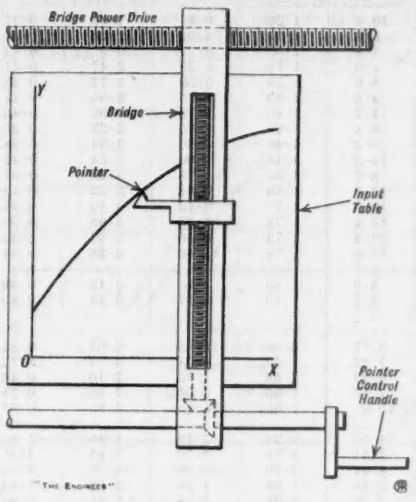

FIG. 4—INPUT TABLE

same interval of time produce a proportional angular movement $\delta\theta$ of the disc.

If the curve laid down on the input table be as shown in Fig. 5 then the object of the machine—or one of its objects—is to draw on another table, the output table, a second curve which is such that the ordinate $e\,e$ at any point is proportional to the area $o\,f\,g\,h$ of the first curve up to the same point. The output table is similar in design to the input table. The movement of the two bridges is derived from the same source of power in order to preserve them equal or proportional. The pointer of the output bridge differs from that of the input bridge in so far

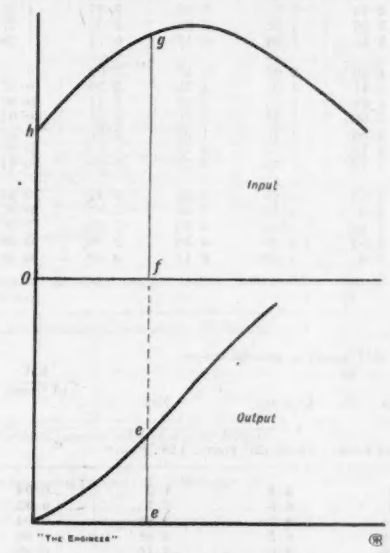

FIG. 5

that it is moved not by a hand drive but by the movement of the wheel in Fig. 2. The output pointer carries a pen or pencil.

The recording of the integrated curve in this manner is useful for a general inspection of the result. A certain amount of practical difficulty may however be caused by the stretching or shrinkage of the paper, while in all cases the numerical evaluation of the result at any instant necessitates the scaling of the curve and a subsequent calculation. As an alternative to the drawing of a curve on the output table use may be made of a counter, or series of counters, of the cyclometer pattern with which the machine is fitted. These counters record the number of rotations made by the wheel, Fig. 2; the figures indicated on them are photographed at regular intervals by means of an automatic camera.

It will be realised that we have now reached a point in our description at which there arises a practical question of critical importance. The integrating wheel, Fig. 2, derives its motion solely from its frictional contact with the disc, but it is required to drive a considerable amount of mechanism, whether the graphical or the counter method of recording the result is used. Considerations affecting the accurate operation of the integrating system prohibit the wheel being pressed against the disc with other than a small force. As a consequence, the friction between the wheel and the disc is far too small to operate the recording mechanism directly without the occurrence of slip. The practical success of the machine therefore turns upon the provision of some means capable of greatly magnifying the small frictional torque applied to the integrating wheel. Two main requirements must be fulfilled by this torque amplifying device. It should magnify the torque without magnifying the motion. In other words, the powerfully driven output end should move strictly at the same speed as the weakly driven, or integrating wheel, end. Secondly, the device should be equally effective in both directions of rotation and should pass from the one to the other without loss of motion. This requirement is imposed by the fact that if the curve to be integrated crosses the x-axis the integrating wheel will move over to the left-hand side of the disc—as seen in Fig. 2—and will therefore reverse its direction of rotation. In this respect the integrating system obeys the familiar mathematical convention whereby areas below the x-axis are regarded as negative. The result of the integration is therefore presented as the difference between the total area above the x-axis and the total area below it. A similar reversal in the direction of rotation of the integrating wheel will occur if the curve to be integrated contains a closed loop.

The principle of the torque amplifier employed is the same as that found in a power-driven capstan. If a rope is coiled once or twice round the drum of the capstan, a light pull applied at the free end of the rope will tighten the coils, increase the friction between the rope and the drum and augment the tension in the rope, according to an exponential law, as it passes round the drum. As a result a light pull on the free end is capable of causing the movement of a heavy load at the other end. The speed of movement of the load and rope will vary with the amount of slip permitted to occur between the rope and the drum. It cannot exceed the peripheral speed of the drum, the condition corresponding to zero slip but it may vary from that value down to zero, the condition corresponding to 100 per cent. slip. Whatever the degree of slip the two ends of the rope will move at equal speed. The only cause which could introduce inequality between the speeds of the two ends would be one causing the length of the rope to change, such, for example, as the varying stretch produced by a variable load. It should be noted, however, that the action is not reversible. Movement of the free end of the rope *towards* the drum loosens the coils but does not cause the loaded end to move *away* from the drum.

The power-driven capstan illustrates the principle applied for the amplification of a linear force. Its application for the purpose of magnifying a torque is illustrated in the diagram Fig. 6. The input shaft

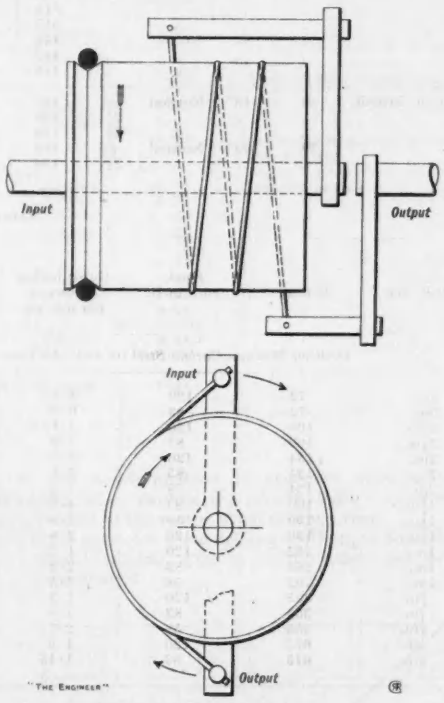

FIG. 6—TORQUE AMPLIFIER

carries, free to rotate on it, a power-driven drum and ends in a crank from which a pin extends back over the drum. A similar crank and pin are provided at the near end of the output shaft. The two pins are connected by a cord coiled once or twice round the drum.

Let us suppose that a considerable resistance to rotation is applied to the output shaft, that the cord is coiled round the drum with some initial degree of tension and that the input shaft is held stationary. In these conditions let the drum be started up under power. The friction between the cord and the drum will build up the tension exponentially in the coils from the input towards the output end of the cord with the result that at the output end the tension may be sufficient to move the output shaft against the resistance applied to it. Any such movement will however be self-destructive. The input end of the cord being stationary, movement of the output shaft under the pull derived from the drum will slacken the coils and reduce the friction and tension. The output shaft will therefore move only slightly, if at all, before coming to rest like the input shaft.

In order that the initial movement of the output shaft may be maintained the coils must be prevented from slackening. To prevent their becoming slack it is necessary to wind the cord on to the drum at the input end at the same rate as it is being wound off at the output end. In other words the input shaft must be rotated at the same speed as the output shaft.

Let us suppose that we rotate the input shaft a little faster than the output shaft. Two results, both acting in the same direction, will follow. The lap of the cord round the drum will be increased and the tension at the input end of the cord will rise. Each of these effects will cause the tension at the output end of the cord to increase with the result that the speed of the output shaft will rise.†

Similarly if we rotate the input shaft a little slower than the output shaft the reduction of the cord lap and of the tension at the input end will lower the tension at the output end with the result that the speed of the output shaft will fall. In both cases the output shaft will suffer just that change of speed required to bring it to equality with the speed of the input shaft. The speed of the input shaft is in this way caused to act as a delicate control over the speed of the output shaft while the torque on the output shaft is multiplied to many times the value of that on the input shaft by the force transmitted to it from the drum.

The arrangement, it is interesting to note, is self-compensatory as regards changes in the coefficient of friction between the cord and the drum. If for instance while the two shafts are rotating at the same speed the frictional coefficient suddenly decreases, as, for example, by the fall of a drop of oil on the drum, then the output tension will decrease and the speed of the output shaft will fall off. As a consequence the lap of the cord will become greater and will assume a new value which will be sufficient to restore the tension and the output speed to the pre-existing values.

If any proof be needed a simple experiment will show that the delicacy of action of the device depends in considerable measure upon the flexibility of the cord. Let a piece of string be coiled two or three times round a half-inch bar rotating in a lathe and let one end of the string be attached to a weight of say 2 lb. resting on a rough horizontal surface. It will be found that a very slight pull on the free end of the string will initiate movement of the weight. If, in fact, the string is of the usual kind it will be noted that its lack of complete flexibility results in a movement of the weight under a pull which is insufficient to keep the free end of the string taut. A very fine silk thread might be used to overcome this difficulty. It has, however, to be remembered that the tension in the thread increases rapidly along the length coiled round the bar. Towards the loaded end flexibility of the cord is less essential. Ideally therefore the cord should be one of which the flexibility increases towards the free, or input, end while the strength increases towards the loaded, or output, end. In practice an approach towards this ideal condition is achieved by the use of a stepped power-driven drum which magnifies the torque in two stages. For the first stage, as indicated in Fig. 7,

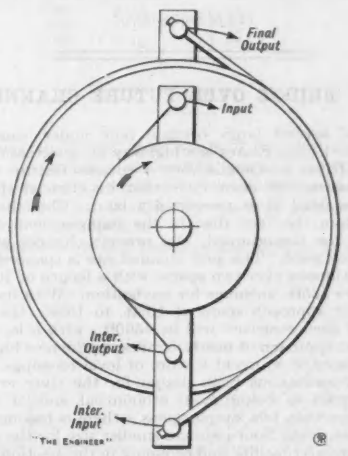

FIG. 7—TWO-STAGE TORQUE AMPLIFIER

a light flexible band, actually a piece of silk-braided fishing line, is coiled two and a half times round the small step of the drum. The output end of this band is attached to a lever to which is also attached the input end of a heavy cord wrapped two and a half times round the large step of the drum. The two coils are of opposite hand.

A small amount of initial tension is applied to the

† The tension T_o at the output end of the cord is related to the tension T_i at the input end by the law $T_o = T_i\, e^{\mu\theta}$, where θ is the angle of lap of the cord and μ is the coefficient of friction between it and the drum.

bands with the result that a certain amount of relative motion must exist between the input and output shafts. It has been found desirable to make this relative motion several degrees—more than it need actually be—and to correct the error thereby introduced by a succeeding device. The amplification of the torque achieved by the two-stepped power-driven drum is of the order of 1 to 10,000.

The arrangement as we have described it so far is unidirectional. It will respond to movement of the integrating wheel in but one direction, the direction of rotation of the power-driven drum. To complete it, it has to be duplicated, the second drum revolving in the opposite direction to the first. This duplicate arrangement is sketched in Fig. 8, simplification being achieved by showing each half with only one stage of torque amplification. The

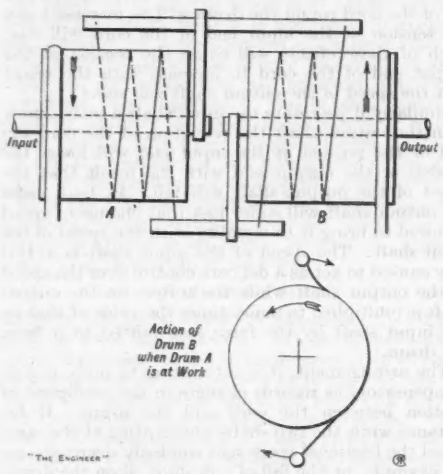

FIG. 8—REVERSIBLE TORQUE AMPLIFIER

left-hand portion is the same as that shown in Fig. 6. If the integrating wheel rotates in the same direction as the left-hand drum the coils on that drum will magnify the torque and cause the output shaft to turn at the same speed in the same direction, the coils on the right-hand drum simultaneously slackening and adding little or nothing to the resistance opposing the rotation of the output shaft. If the integrating wheel rotates in the opposite direction the right-hand drum amplifies the torque while the coils on the left-hand drum slacken.

The complete amplifier possesses several features of great general interest. One of the most striking is that it is virtually a mechanical edition of a thermionic valve. It reproduces the properties of its electrical equivalent even to the extent that it may develop self-oscillation as a result, apparently, of some portion of the output being fed back to the input. This defect in the early stages of the development of the device caused much trouble and led at times to the wrecking of it. The trouble was cured by mounting loosely on the output shaft a substantial fly-wheel which was driven by the shaft through friction generated by pressure against a felt washer. Uniform rotation of the shaft results in the fly-wheel rotating with it, but oscillatory motion causes it to slip and introduce a damping force. The use of this fly-wheel is analogous to the introduction of resistance by a transformer coupling into a thermionic valve circuit.

(To be continued.)

LONG BRIDGE OVER FUTURE CHANNEL.

ONE of several large bridges now under construction in the United States is a highway bridge crossing the Missouri River at Omalia, but a curious feature which greatly assists the erection is that its channel span is built over what is at present dry land. This situation results from the fact that in the improvement of the river by the Government, the present channel will be shifted westward. This new channel site is spanned by a truss continuous over two spans, with a length of 1050ft., giving two 525ft. openings for navigation. With its truss and girder approach spans of 100ft. to 160ft., the total length of steel structure will be 4500ft., with a long embankment approach of nearly 5 miles, as the new highway will be elevated to avoid a score of level crossings. The two-span continuous truss design for the river crossing was adopted as being more economical and of better appearance than two simple spans; there is less metal in the trusses, fewer floor joints, a smaller size for the centre pier and greater facility and economy in the erection work. The trusses are spaced 28ft. between centres and have bays or panels 33ft. long. For the roadway, 22ft. 6in. wide, there are three lines of longitudinal plate girder bearers carrying transverse rolled steel joists, 39in. apart, on which is laid the concrete slab. All the other spans have deck trusses or deck girders. This bridge is being built by the city, as the present bridge is further upstream, and on an indirect route. Its estimated cost is £330,000, of which one-third is a grant from the Government and the remainder a Government loan. To provide for repayment of the loan, tolls will be charged for a term of years, after which the bridge will be free or with a low rate of toll to cover working expenses and maintenance. The main span was cantilevered from one end, two temporary steel piers supporting it in each 525ft. opening.

DRILLING COPPER TUBE PLATES

(For description see opposite page.)

TABLE I.—*Drilling Copper Tube Plates.*

Brinell hardness of plate.	Drills. Helix angle.	Drills. Point angle.	Drills. Cutting edge.	Drill dia., inches.	R.p.m.	Feed cuts per inch.	Cubic inches removed per min.	KW input to motor. Light.	KW input to motor. Drilling.	KW input to motor. Net.	Net kW in.³/min.
Annealed fire-box tube plate, 47·7 Brinell	29°	118°	Normal	1 1/16	355	83	10·4	1·55	9·5	7·95	0·77
	29°	118°	Lipped	1	615	83	5·8	1·75	4·0	2·25	0·38
	,,	,,	,,	1 1/16	830	83	8·1	2·00	5·5	3·5	0·43
	,,	,,	,,	1 1/16	615	83	6·0	1·78	4·25	2·47	0·41
	,,	,,	,,	1 1/16	615	58	8·6	1·78	5·50	3·73	0·43
	,,	,,	,,	1 1/16	190	58	9·6	1·80	5·75	3·95	0·41
	,,	,,	,,	,,	190	38	14·7	1·80	7·75	5·95	0·40
	,,	,,	,,	,,	262	120	6·4	1·46	3·69	2·23	0·35
	,,	,,	,,	,,	262	83	9·3	1·46	5·00	3·54	0·38
	,,	,,	,,	,,	262	58	13·2	1·46	7·00	5·54	0·42
	,,	,,	,,	,,	355	120	8·7	1·55	4·75	3·20	0·37
	,,	,,	,,	,,	355	83	12·6	1·55	6·88	5·33	0·42
	,,	,,	,,	,,	443	120	10·8	1·73	6·13	4·40	0·41
	,,	,,	,,	,,	443	83	15·7	1·73	7·38	5·65	0·36
	,,	,,	,,	,,	443	58	22·3	1·73	9·56	7·83	0·35
	,,	,,	,,	,,	615	83	21·8	1·78	11·06	9·28	0·44
	Trepanning with two ⅜in. wide tools, 36° top rake			4 1/16	100	120	5·6	1·15	3·3	2·15	0·38
				,,	100	83	8·1	1·15	4·37	3·22	0·40
Ditto 52 Brinell	29°	118°	Normal	7/16	615	120	0·77	2·00	2·62	0·62	0·81
	,,	,,	,,	1½	355	120	5·22	1·65	5·38	3·73	0·72
	29°	118°	Lipped	1½	355	120	5·22	1·65	3·75	2·10	0·40
	,,	,,	,,	,,	355	83	7·55	1·65	4·50	2·85	0·38
	,,	,,	,,	,,	355	58	10·8	1·65	5·60	3·95	0·37
Cold-rolled deoxidised copper plate, 56 Brinell	45°	150°	Normal	33/64	830	120	4·60	2·32	7·12	4·80	1·04
	,,	,,	,,	,,	615	120	3·41	2·10	5·75	3·65	1·07
	,,	,,	,,	,,	615	83	4·44	2·10	6·88	4·78	1·08
	,,	,,	,,	,,	443	120	2·46	1·98	4·50	2·52	1·02
	,,	,,	,,	,,	443	83	3·56	1·98	5·38	3·40	0·96
	,,	,,	,,	,,	443	58	5·10	1·98	6·63	4·65	0·91
	45°	118°	Normal	33/64	830	120	4·60	2·05	7·37	5·32	1·16
	,,	,,	,,	,,	830	83	6·62	2·05	9·50	7·45	1·13
	,,	,,	,,	,,	615	120	3·41	1·98	5·90	3·92	1·15
	,,	,,	,,	,,	615	83	4·94	1·98	7·38	5·40	1·10
	45°	90°	Normal	33/64	830	120	4·60	2·05	7·62	5·57	1·21
	,,	,,	,,	,,	615	120	3·41	1·98	6·25	4·30	1·26
	,,	,,	,,	,,	615	83	4·94	1·98	7·69	5·74	1·16
	,,	,,	,,	,,	443	83	3·56	1·75	6·25	4·50	1·26
	,,	,,	,,	,,	443	58	5·10	1·75	7·50	5·75	1·13
	29°	90°	Normal	33/64	615	120	3·41	1·98	6·88	4·90	1·44
	,,	,,	,,	,,	830	120	4·60	2·05	8·58	6·53	1·42
	29°	150°	Normal	33/64	830	120	4·60	2·32	8·62	6·30	1·37
	,,	,,	,,	,,	615	120	3·41	2·10	7·12	5·02	1·47
	,,	,,	,,	,,	615	83	4·94	2·10	8·62	6·52	1·33
	,,	,,	,,	,,	443	120	2·46	1·98	5·25	3·27	1·34
	,,	,,	,,	,,	443	83	3·56	1·98	6·50	4·52	1·27
	,,	,,	,,	,,	443	58	5·10	1·98	8·12	6·14	1·24
	29°	118°	Lipped	33/64	830	120	4·60	2·05	5·13	3·08	0·67
	,,	,,	,,	,,	615	120	3·41	1·95	4·25	2·30	0·67
	,,	,,	,,	,,	615	83	4·94	1·95	5·06	3·11	0·63
	,,	,,	,,	,,	615	58	7·08	1·95	6·50	4·55	0·64
	,,	,,	,,	,,	443	120	3·56	1·75	4·00	2·25	0·63
	,,	,,	,,	,,	443	83	5·10	1·75	4·79	3·04	0·60
	,,	,,	,,	,,	443	58	7·78	1·75	6·75	5·00	0·64
Ditto 60 Brinell	29°	118°	Normal	1 1/16	443	120	2·55	2·25	4·65	2·40	0·94
	,,	,,	,,	2 3/16	134	120	5·0	1·53	6·40	4·87	0·97
	,,	,,	,,	2 3/16	134	83	7·20	1·53	8·75	7·22	1·00
	29°	125°	Normal	1 1/16	443	120	2·55	2·25	4·50	2·25	0·88
	,,	,,	,,	2 3/16	134	120	5·0	1·53	6·13	4·60	0·92

TABLE II.

Drill dia.	R.p.m.	Feed, cuts/inch.	Cubic inches removed per minute.	kW input to spindle motor. Light.	kW input to spindle motor. Drilling.	kW input to spindle motor. Net.	kW / in.³/min.
Drilling Medium Carbon Steel (0·45 C, 42 Tons per Square Inch); Drills 29° Helix, 118° Point.							
3in.	72	120	4·25	0·8	4·8	4·0	0·94
3in.	72	83	6·2	0·8	6·5	5·7	0·92
2½in.	100	120	4·1	0·82	4·7	3·88	0·94
2½in.	100	83	5·9	0·82	6·5	5·68	0·96
2in.	134	120	3·5	0·90	4·0	3·10	0·89
2in.	134	83	5·1	0·90	5·37	4·47	0·88
2in.	134	58	7·3	0·90	7·62	6·72	0·92
1½in.	190	83	4·1	1·07	4·5	3·43	0·84
1½in.	190	58	5·8	1·07	5·82	4·75	0·82
1½in.	190	120	2·8	1·07	3·5	2·43	0·87
1in.	262	120	1·7	1·17	2·7	1·53	0·90
1in.	262	83	2·4	1·17	3·25	2·08	0·87
1in.	262	58	3·5	1·17	4·25	3·08	0·85
¾in.	355	120	1·3	1·27	2·35	1·08	0·91
¾in.	355	83	1·9	1·27	3·0	1·73	0·91
¾in.	355	58	2·7	1·27	3·7	2·43	0·90
½in.	615	120	1·0	2·05	2·95	0·90	0·90
½in.	615	83	1·45	2·05	3·25	1·20	0·83
Drilling Mild Steel (31 Tons per Square Inch); Drills 29° Helix, 118° Point.							
3in.	72	83	6·20	0·80	6·25	5·45	0·88
2 7/16in.	134	83	6·2	0·90	6·12	5·22	0·84
1½in.	190	83	5·5	1·07	5·50	4·43	0·80
1½in.	190	83	2·82	1·07	3·35	2·28	0·81
1in.	443	83	4·2	1·70	5·1	3·4	0·81
1 1/16in.	355	83	2·95	1·27	3·5	2·23	0·76
1 1/16in.	355	58	4·22	1·27	4·5	3·23	0·77
Trepanning Mild Steel.							
3 7/16in. O.D. tools ⅛in. wide	72	120	2·88	0·80	2·9	2·1	0·73
	72	83	4·17	0·80	3·9	3·1	0·74
	72	58	5·97	0·80	5·1	4·3	0·72
	100	83	5·8	0·82	5·0	4·18	0·72
11 1/16in. O.D. tools ⅛in. wide	28	120	3·0	0·75	2·9	2·15	0·72
	28	83	4·4	0·75	4·0	3·25	0·74
	28	58	6·3	0·75	5·15	4·4	0·70

Drilling Copper Tube Plates.

(By a Correspondent.)

THE drilling of copper is an unusual operation in most workshops and few data are available to those meeting it for the first time. On the other hand, in locomotive boiler construction it is a matter of prime importance and daily experience.

Copper being a soft ductile material, the natural inference is that it would be easy to drill, and the power requirements small; actual experience at once disproves this, and the author puts forward the following notes to help those who have to meet this problem.

When seeking maximum production in drilling copper tube plates, three phases of this problem arise—power consumption, finish of the hole, and drill life between grinds.

Power Consumption.

Practically all investigations of the power consumption of twist drills have been summarised in expressions of the exponential type, a method which is not dimensionally correct. As twist drills of different sizes are dimensionally similar tools, with the same proportionate length of cutting edge to diameter, and the same variation of cutting rake angles along this cutting edge, the cutting torque should be a function of $d^3 \times$ feed per revolution, and of the material cut. The reason why most investigators have not agreed with this expression is probably that one exponential term obtained by logarithmic plotting has been sought to co-ordinate the results obtained without thought being given to the known variation that may occur in the shape of the cutting edge of twist drills as commercially produced, the variations due to drill grinding, and to the fact that the remaining component of power consumption of a twist drill, apart from cutting action, namely, friction of the drill in the hole, is not necessarily a function of the rate of feed. In this short paragraph the author trusts he has indicated reasons (to which he hopes to return at a later date) for the basic accuracy of the assumption that as a first approximation at least, torque varies as $d^2 \times$ feed, and horse-power consumed at the drill as $N \cdot d^2 \cdot f$, or as the cubic inches of metal removed per minute. The following figures have been analysed on this basis. Proceeding; it is true that at any particular spindle speed of a drilling machine:—

Kw input to spindle motor × motor eff. × machine eff. = kW used at the spindle.

Now the efficiency of the machine itself can be divided into two terms, the oil churning losses, constant at any speed for all loads, and the gear and bearing losses, proportional to the load. Hence

kW input to spindle motor =

(kW at spindle ÷ eff. of m/c + m/c no-load losses) ÷ motor eff.

Over the usual range of power consumption when drilling, *i.e.*, from half load to 1½ full load, the motor efficiency is almost constant; over the same range the machine efficiency is similarly almost constant, although this latter varies slightly at different speeds of the spindle. As typical values, motor efficiency would range between 80 and 85 per cent. and the machine efficiency of a drilling machine with motor on the saddle, of modern construction, with a spindle speed range of, say, 50 to 1, would range between 85 and 88 per cent. Thus

kW input to motor when drilling = (const. × kW at drill + m/c no-load losses) ÷ motor eff.

If the approximation is accepted that motor efficiency when driving the spindle light is approximately that of the motor when drilling, then

kW input to motor when drilling − kW input to motor when running spindle light = const × net kW used at drill.

and, finally, therefore

Net kW input to spindle motor = constant × cubic inches of metal removed per minute . . . (1)

The above expression is not new. It is fairly widely used as a means of checking results in many classes of tools, and may have appeared doubtful to some readers when compared with the more elaborate exponential expressions proposed by many investigators to cover the results of their work, but the author contends that this simpler expression has a sounder basis, and as the following results show, it answers admirably when applied to drilling machine data.

In Table I, opposite, the results obtained when drilling copper tube plates of four different Brinell hardness values with twist drills of various combinations of point angle and flute angle are given and plotted in Figs. 1*a* *b*, *c*, *d*, and in Table II and Figs 2*a* and 2*b*, the results obtained in drilling mild steel and medium carbon steel are given for comparison. All these tests were carried out in the same drilling machine. From the above a summary has been prepared in Table III, from which three conclusions can be drawn—the power consumption for drilling copper with normal type twist drills (*i.e.*, 29 deg. helix and 118 deg. point) is considerably more than for drilling steel; varying the point angle and helix angle of the drill alters the power consumption somewhat, but it is necessary to grind the cutting edge of the twist drill with a pronounced lip (Fig. 3) to achieve a very material drop in power consumption.

Comparison of the power consumption figures for

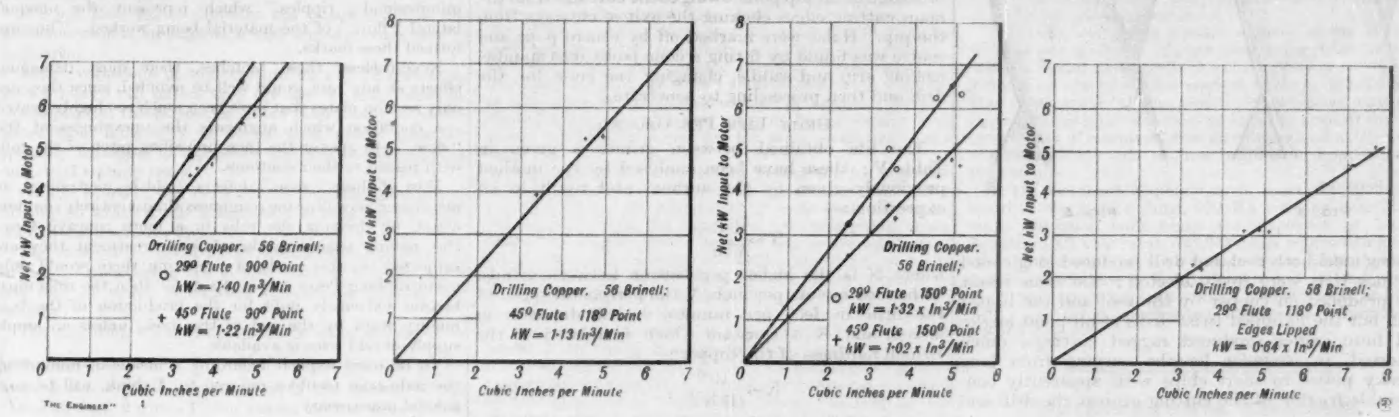

FIG. 1 (*a*, *b*, *c*, *d*)—DRILLING COPPER TUBE PLATES

Table III.

Material cut.	Helix angle of drill.	Point angle of drill.	Cutting edge.	Net kW Input to motor per cubic inch removed per minute.
Medium carbon steel, 42 tons per square inch	29°	118°	Normal	0·90
Mild steel, 31 tons per square inch	29°	118°	Normal	0·81
Trepanning mild steel	—	—	—	0·72
Annealed fire-box copper tube plate, 47·7 Brinell	29°	118°	Normal	0·76
	29°	118°	lipped	0·40
Ditto, trepanning	36° Top rake	—	—	0·39
Annealed fire-box copper tube plate, 52 Brinell	29°	118°	Normal	0·72
	29°	118°	lipped	0·37
Cold rolled copper tube plate, 56 Brinell	45°	90°	Normal	1·22
	45°	118°	,,	1·13
	45°	150°	,,	1·02
	29°	90°	,,	1·40
	29°	150°	,,	1·32
	29°	118°	lipped	0·64
Cold rolled copper tube plate, 60 Brinell	29°	118°	Normal	0·98
	29°	125°	Normal	0·91
Pure annealed copper, 40·4 Brinell*	29°/31°	120°/121°	Normal	1·34

* Boston and Oxford, see METALLURGIST, February, 1930, p. 21.

Table IV.

Material drilled.	Helix angle of drill.	Point angle of drill.	Net kW input to motor per cubic inch per minute. Calculated.	Experimental with normal drills.	Experimental with lipped drills.
Mild steel, 29·4, tons per sq. inch	29°	118°	0·71	0·81 drilling 0·72 trepanning	
Medium carbon steel, 48·9 tons per sq. inch	29°	118°	0·77	0·90 drilling	
Annealed copper	15°	90°	0·56		
	,,	118°	0·55		
	,,	150°	0·55		
	,,	180°	0·54		
	29°	90°	0·52	1·40	—
		118°	0·51	0·72, 0·76, 1·36	0·37, 0·40, 0·64
		150°	0·50	1·32	—
		180°	0·49	—	—
	45°	90°	0·46	1·22	
		118°	0·42	1·13	
		150°	0·40	1·02	
		180°	0·39	—	

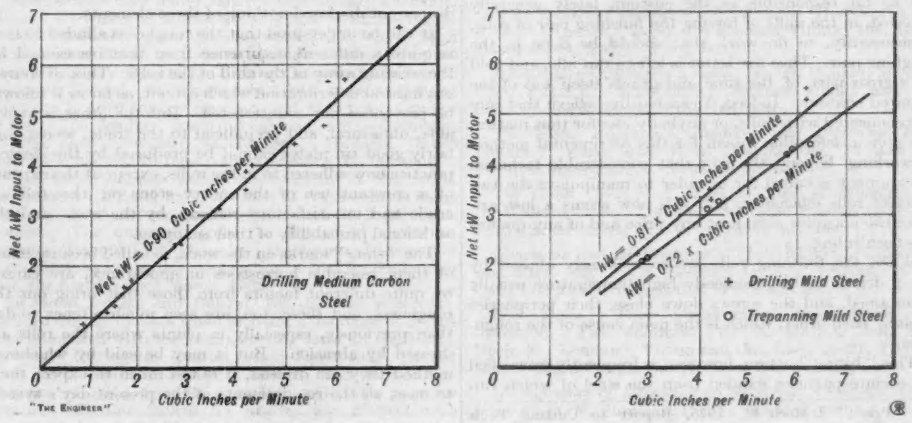
Net kW Input to Motor
Cubic Inches per Minute
Net kW = 0·90 Cubic Inches per Minute
Drilling Medium Carbon Steel
kW = 0·81 x Cubic Inches per Minute
kW = 0·72 x Cubic Inches per Minute
+ Drilling Mild Steel
○ Trepanning Mild Steel

FIG. 2 (*a* and *b*)—DRILLING STEEL

trepanning leads to the conclusion that, whereas the power consumption of a twist drill and the trepanning tool were the same when operating on mild steel, the power consumption of the tool was much lower than a normal drill when cutting copper, but was the same as the lip-ground twist drill. The form of cuttings produced threw further light on this matter; when

FIG. 3

FIG. 4

cutting steel both tool and drill produced long coiled cuttings that were freely ejected; the same result was produced on copper by the tool and the lipped drill, but the unlipped twist drills of all point angles and flute angles produced ragged cuttings, much distorted, in irregular lengths varying from long streaky pieces to short chips with apparently considerable friction of the cutting against the drill and against the hole, which was always rough in finish. Thus the large improvement in power consumption secured by lipping the drill for copper would appear to be chiefly due to reduction in useless work done on the cuttings after severance from the work piece and only in a minor degree to the change in cutting rake angle of the edge of the drill. As a final check theoretical values for the power consumption were obtained by using Stanton and Hyde's* curves of cutting pressure variation with cutting angle and integrating these graphically along the cutting edge of drills for various combinations of helix angle and point angle for copper, mild steel, and medium-carbon steel. The results are given in Table IV, from which it will be seen that reasonable agreement is obtained with the experimental results for mild steel, medium-carbon steel, and for copper with lipped drills, but not for normally ground drills cutting copper.

FINISH OF HOLE.

As indicated above, good finish was difficult to obtain with normally ground drills, but quite satisfactory finish was obtained with the lip-ground drills; in fact, minimum power consumption and good finish went hand in hand up to peripheral speeds as high as 225ft. per minute; several trials were made with drills ground with a centre pip—Fig. 4—and whereas this improved the finish, it did not reduce the power consumption and some difficulty was experienced with breakage of the pip point owing to the cuttings from the main cutting edges choking the exit of cuttings from the pip. Holes were marked off by centre pops and centre was found by fitting a cone point into spindle, locking arm and saddle, changing the cone for the drill and then proceeding to penetrate.

DRILL LIFE PER GROUND.

The life obtained between grinds is given in Table V; these have been analysed by the method previously given by the author† and result in an expression:—

$$N=\frac{K\,C}{V^3 d} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

where N is the inches penetration between grinds, C the feed in cuts per inch, V the peripheral speed of the drill in feet per minute, d drill diameter in inches, and K a constant which is related to the Brinell hardness of the copper:—

$$K=\frac{10^{29}}{(B\,N)^{13}} \quad . \quad . \quad . \quad . \quad . \quad . \quad (3)$$

TABLE V.

d, inches.	R, r.p.m.	C, cuts per in.	V, ft. per min.	Brinell hardness of copper.	Number of holes drilled.	Thickness drilled, inches.	N total distance drilled. Actual.	N total distance drilled. Calculated.
1/16	443	120	108·7	60	20	4	80	76
2/16	134	120	78·9	60	24	4	96	83
3/16	830	120	200·3	56	12	2¼	27	30
3/16	615	83	148·5	56	18	2¼	40½	52
3/16	443	83	106·9	56	54	2¼	121½	138
3/16	443	58	106·9	56	44	2¼	99	97
1 1/16	443	83	224·7	47·7	55	1 3/16	65	57

The calculated value for N has been added to Table V to compare with the experimental value.

CONCLUSION.

From the preceding notes it will be seen that, provided drills are suitably ground, there is no necessity to equip machines for copper drilling with larger motors than are normally used on drilling machines; in fact, the motor size may be reduced if the machine is to be isolated for drilling copper only. Suitable peripheral speed range giving good tool life and good finish is 130ft. to 150ft. per minute, and large holes for superheater flue tubes can be trepanned quite well up to 100ft. per minute.

* "Proc.," I. Mech. E., 1925, Report to Cutting Tools Research Committee.

† THE ENGINEER, August 17th, 1934, p. 160.

Letters to the Editor.

(We do not hold ourselves responsible for the opinions of our correspondents.)

ROUGHNESS AND "SHOE" MARKS ON TIN-PLATE.

SIR,—The roughness seen on tin-plate mill rolls and the "shoe" marks on the work are more prevalent to-day than ever, so have become a rather serious and costly trouble. These blemishes are often seen on the plates even after they are tinned, despite all efforts to neutralise them.

Neither of these deteriorating appearances was known when the output of the mills was about half of what it is now. Nevertheless, the greatly increased production is not so far responsible as the custom, lately generally followed, in the mills of forcing the finishing pair of rolls, unnecessarily, to do work that should be done in the roughing pair. Thus the latter is left to run idle, and cold for a great part of the time and grinds itself out of the required contour. Indeed, I can hardly believe that any one connected with mills, or anybody else for that matter, can give a defensible reason for this detrimental method of working, beyond the fact that considerable technical discernment is called for in order to manipulate the two pairs of rolls efficiently, and this now seems a lost art, since the craze for output at any price and of any quality has been ruling.

When the finishing rolls are so recklessly abused by being driven to the needlessly high temperature usually maintained, and the screws down close, their peripheries "bite" each other, which is the main cause of the roughness.

This "biting" action, however, is frequently intensified by minute particles exuded from the steel of which tin-plates are generally made to-day as the work passes through the rolls. These particles adhere to the rolls' peripheries.

This efflux was never known until steel tin-plate bars were brought into use, which, we are told, are chiefly produced from scrap iron, therefore contain many metallic elements, certain particles of which escape, as mentioned. I am assured of this eventuality, if an analysis can be relied upon, because I had one taken a short time ago of a portion of the first turning cut of a roll that had worked a week, when distinct traces, especially of aluminium and copper, were clearly shown, whereas one analysis of a deeper cut disclosed nothing of these elements.

It will be understood that the roughness alluded to here is quite a different occurrence from that occasioned by the wearing away of the chill of the rolls. This, of course, is a natural deterioration which cannot, as far as is known, be prevented nor counteracted. But the other is avoidable, unnatural, and prejudicial to the trade, seeing that fairly good tin-plates cannot be produced by the illogical practice now adhered to in the mills, except at the expense of a constant use of the emery stone on the rolls—a crude and unsatisfactory remedy, by the way—and the additional probability of their snapping.

The "shoe" marks on the work, so called because many of them resemble horseshoes in appearance, are caused by quite different factors from those that bring out the roughness, and these, too, are seen much oftener to-day than previously, especially in plants where the rolls are dressed by abrasion. But it may be said by whichever method they are dressed, it is too much to expect them to meet all the requirements of the present-day's system of working satisfactorily, since at the beginning of the week—assuming they are dressed at week-ends, as is generally the custom—their concavity is not sufficient to allow of the maximum quality of tin-plates being regularly turned out, and at the end it is too pronounced.

These "shoe" disfigurements are most often found, if at all, near the sides or edges of the work done the first day or two after the rolls have been newly dressed, and they are due to the heavier pressure of the rolls on the middles of the work passing through them than on the sides; hence reducing the substance of the latter at a slightly slower rate, which develops a tendency to pucker, or, in the phraseology of the mills, "pinch" the work. These different degrees of pressure, however, are rarely great enough to "pinch" the plates, yet they frequently do the next thing to it, that is, create a continuity of infinitesimal "ripples," which represent the unequal lateral "flow" of the material being worked. Thus are formed these marks.

Nevertheless, these blotches, their most damaging effects at any rate, could well be avoided, since they are only seen on plates that have been much too highly heated—a condition which augments the unevenness of the "flow"—to answer the then prevailing pitch of the rolls with regard to their contours.

Most of these "shoe" defects could be neutralised, as mentioned, as well as the roughness almost entirely counteracted, by dressing the rolls to a more concave form. But having regard to the abusive treatment they are subjected to, this mode of preparing them would only mean robbing Peter to pay Paul, for then the rolls must become extremely unfit for the production of the best quality work by the end of the week, unless an ample supply of odd sizes is available.

To be more explicit regarding a means of minimising the industrial troubles referred to, I think, will be considered unnecessary.

JOHN WILLIAMS.

Banwen, Pontardawe, July 13th.

OIL-ELECTRIC PADDLE SHIPS.

SIR,—The Clyde passenger ship "Talisman," described in the current issue of THE ENGINEER, affords an example of the tendency of electrical engineers to apply electricity to anything and everything; to lose the mechanical instinct and sense of the fitness of things.

The most suitable power plant for the vessel would surely have been a geared turbine with water-tube boiler generating steam at high pressure and superheat, and using pulverised coal as fuel. As the trips are short, it appears to be a suitable case for carrying sufficient fuel in the bunkers for the outward and return trips, the pulverising plant being located at the point of departure.

Given the owners' desire for a compression ignition internal combustion engine plant, however, the most suitable unit would appear to be a horizontal *vis-à-vis* engine developing 1600 h.p. in six or eight cylinders, and geared to the paddle shaft direct, or through a hydraulic coupling to give increased flexibility in manœuvring.

The power plant installed may give extreme flexibility, but in other respects it is by no means efficient. It is an axiom that the greater the power output per cylinder the higher the thermal efficiency. In this case there are no less than thirty-two cylinders to produce the low output of 1600 h.p., which is absorbed by eight generators, four main and four auxiliary machines.

Consider the multiplicity of reciprocating parts—pistons, connecting-rods, valves, and valve rods, the numerous tappets, cam shafts, main and big-end bearings, fuel pumps, and injector valves. These medium-speed C.I. engines require high-grade Diesel oil, the most expensive fuel for a ship. It will be of interest to see the running cost figures, fuel and lubricating oil consumption, and, after a few years, the upkeep costs of the engines.

Mechanically, the scheme is inferior to one using the *vis-à-vis* engine previously referred to. This type of engine is compact, and the low headroom required is an advantage for ship propulsion.

It would be of interest to compare the capital and running costs of:—

(*a*) The multi-engined electric drive installed;

(*b*) An eight-cylinder horizontal *vis-à-vis* engine geared to the paddle shaft, with or without a hydraulic coupling;

(*c*) A geared steam turbine and pulverised coal fuel, water-tube boiler, embodying the results of recent proven advances in design and practice.

E. B. PARKER.

Hutton, Essex, July 9th.

WELDED RAILS.

SIR,—Perhaps you will allow a physicist to make one or two comments on the articles which have appeared recently in THE ENGINEER (June 7th) on the subject of continuous welded rails.

It appears that, as a matter of experience, very long rails do not expand with the temperature proportionately more than do rails of ordinary length, and several explanations of the discrepancy are put forward.

It is suggested, for instance, that the expansion of a long rail takes the form of minute corrugations (presumably between the chairs), or, as a second possibility, that the expansion takes place "in all directions."

But it is difficult to see why either of these effects should be found with long rails rather than short, or why they should have less disastrous consequences.

A third hypothesis, requiring more detailed consideration, is that great lengths of continuous rail are exposed to regions of local cooling, which partly compensate the expansion due to regions of excessive heating.

This effect will also be found with rails of ordinary length, though to a less extent, and clearly it may even cause adjacent rails to expand and contract alternately. The effect of such a fluctuating distribution of temperature is to produce expansion varying as the square root of the length, or, more precisely, that the probability of a given total expansion (or contraction) increases with the square root of the length. Thus, a 600ft. welded rail would expand about three times as much as an ordinary 60ft. rail. But without careful examination of the conditions, it would be unwise to attach great importance to such average values.

We are thus led to consider the possibility that the allowances made for expansion with ordinary track may be excessive.

Large variations of temperature do not penetrate far into a heavy rail unless they are also of long duration. Consequently, the expansion is less than would be anticipated from laboratory or works tests, unless these are specially arranged to reproduce the conditions occurring on actual railway track.

As you yourself, Sir, have pointed out, the most severe heating to which a rail is subjected is that due to direct sunlight on a summer day.

The order of the effect in the interior of the rail may be found by considering the simple case of a thick plate, one face of which is exposed to periodic heating and cooling.

The amplitude of the temperature variation at a depth x is then proportional to $e^{-x\sqrt{\omega\rho C/2k}}$, where C is the specific heat, k the thermal conductivity, ρ the density of the material, and $2\pi/\omega = T$ the period of the disturbance. In the case of steel, if the period is an hour, we find $\sqrt{\frac{\omega\rho C}{2k}} \doteq \cdot 10$ cm.$^{-1}$, so that at a depth of 10 cm. the amplitude will have fallen nearly to one-third of its value at the surface.

It appears, therefore, that the average temperature, and, consequently, the linear expansion, will be relatively insensitive to very intense heating of one surface, even if this is maintained for an hour or more.

These considerations support the view put forward in your leading article, that unequal heating, and not uniform expansion, is the chief cause of track failure, and to this the continuous welded rail is presumably no more liable than a rail of ordinary length, nor are the stresses involved likely to be more dangerous.

July 9th. J. H. BRUCE.

ROTARY, ANNULAR, AND TANDEM COMPOUND BEAMS.

SIR,—I should greatly value any information I could get, and illustrations, of the annular compound rotary beam engines once widely used around London for corn mills. Can anyone tell me of an extant one, even derelict? Simpsons (now Worthington) built some, I believe, for pumping in 1860–70. Have any beam engines been built since the war? Could anyone refer me to an illustration of a tandem compound beam engine such as the Allis sets once at Milwaukee?

G. WATKINS.

Granby House, St. Michael's, Bristol, 2.
July 16th.

Nationalism and Overseas Trade.

A FEW days ago, Major L. C. Cripps, Chairman of Council, gave an address to the British Chamber of Commerce in Liverpool on our trade with the Netherland East Indies. There was in the address but little specific reference to the engineering and allied industries, but a good part of it was devoted to a broad problem connected with overseas trade, which is of no less importance to engineering manufacturers and traders than to those engaged in other branches of commerce. Aware of the lively interest which engineers are now showing in economic problems, we print the following passage from Major Cripps' address in the certainty that whilst the reactions to them may vary, all will appreciate the importance of the matters discussed.

"The Netherlands Indies trade in 1934 has therefore continued to readjust itself in relation to the international position of the guilder. Such readjustment must of necessity be a slow process, but on the whole the results are not unsatisfactory. International trade has a resiliency which ultimately overcomes the difficulties manufactured by mankind and common sense has a habit of ultimately re-asserting itself. On the whole, I think I may say that a very slow recovery, which is probably the most satisfactory state of affairs, is gradually taking place. Unfortunately for European trade, the adjustment is coming about very largely in the East and is resulting in Japan taking the place held in pre-war days by Europe.

"I gave you, in my review of trade last year, an account of the poverty of the native population who had been thrown out of employment by the refusal of their old clients to buy many of those products which the natives had regularly supplied to them in increasing quantities during the last half century. I propose now to deal with the developments which have taken place to meet the situation which has arisen. The more enterprising of the population have discovered that under the existing conditions of depression they can obtain labour in the N.E.I. at a low rate of wages and with this labour can produce the goods which have up to recent times been imported from Europe in exchange for native agricultural products. So we see various Government measures limiting the period for importing various manufactured articles, including Kaffir pots, unbleached shirtings, window and other forms of glass, food carriers, wash-basins, kettles, and other forms of table and kitchen utensils, bicycles and accessories. No doubt in due course native industry will supply all the needs in these trades. New factories are springing up all over the islands, the most notable being a new tin and sheet iron factory, an electrical factory, a chocolate factory, and two more weaving mills.

"I would like to stress here that the erection of these factories has been forced on to the Netherland East Indies by the exclusion of their agricultural products from Europe and America. As a result of this exclusion they have been unable to buy their requirements from those countries which previously supplied them.

"As far as this country is concerned we used, as you all know, to purchase sugar from Java, and the Javanese used the credits raised by these and other sales in England to purchase the sugar machinery and other requirements, such as clothing and cooking utensils. These, they are now being forced to produce for themselves or do without, as they have no available balances in England for purchasing them, and, of course, they no longer require from us the artificial fertilisers for the land previously under sugar.

"In Britain the consumer is paying for his sugar at world prices, but he is also providing some six millions a year to subsidise the cultivation of sugar beet. The purchasing capacity of the consumers has consequently been reduced by £6,000,000 per annum. Meanwhile numbers of people who were employed in sending manufactured goods to Java are now out of employment. This tendency to buy in the most expensive shop, or, in other words, to take in your own washing when your laundry is quite unsuitable for the work, is amongst the most outstanding of modern times. I am certain that the results on balance are not to create employment, but to create unemployment and to prevent the maximum exchange of goods amongst mankind by forcing people to buy at high prices. As long as this tendency goes on Governments must be made to realise that they are creating unemployment and that their best course is to leave industry and agriculture to operate on the basis of trial and error.

"No opportunity should be lost of withdrawing subsidies and artificial restrictions of every kind. There may be much to be said for a rubber restrictionist scheme which restricts the amount put on the market and counteracts the evil effects of previous over-investment. No such argument can be used in support of a wheat or sugar subsidy or quota which merely accentuates the over-production and over-investment which such schemes as that applied to rubber are designed to remedy. The folly of man seems to have come the full circle. On the one hand we are spending money and putting into operation schemes designed to reduce stocks so as to enable the producer to obtain a remunerative price for his products. Hence the regulations applied to rubber, tea, and tin and proposals such as the scrapping of spindles. Here we are paying for the mistaken policies of over-capitalisation pursued in previous years. On the other hand, we are directly encouraging such over-investment and over-production by sinking the taxpayers' money in the uneconomic production of sugar, wheat, and other products. No doubt in years to come the unhappy consumer will be taxed in order to compensate those whose money has been artificially attracted towards these mushroom industries, brought into existence solely by the various subsidies offered so freely by the Minister of Agriculture. What we need as soon as practicable is the survival of the fittest among producers and freedom for the consumer to purchase his requirements where he can obtain the best return. Perhaps the common sense which we are supposed to possess in this country may finally reassert itself and such a policy as this may at last find widespread support."

The Quarter's Shipbuilding Returns.

THE statistics issued by Lloyd's Register of Shipping regarding merchant vessels under construction at the end of June last show that in Great Britain and Ireland there is an increase of 4506 tons in the work in hand as compared with the figures for the previous quarter. The present total of tonnage under construction—560,321 tons—is, however, 26,821 tons less than the tonnage which was being built at the end of June, 1934, but exceeds the aggregate tonnage now under construction in the five leading countries abroad.

The tonnage on which work was suspended at the end of June last amounted to 23,288 tons, being composed entirely of steamers. About 79,000 tons—14 per cent. of the tonnage now being built in this country—are intended for registration abroad or for sale.

The tonnage now under construction abroad, excluding Russia, for which no figures are available—722,210 tons—is about 8500 tons more than the work which was in hand at the end of March last, and is the highest quarterly total recorded since June, 1932. Tonnage, included in the total in hand abroad, on which work has been suspended amounts to 1000 tons of steamers and 8745 tons of motor ships. The leading countries abroad are:—Germany, 237,045 tons; Sweden, 94,473 tons; Holland, 75,446 tons; Japan, 65,970 tons; and Denmark, 65,753 tons.

The total tonnage under construction in the world amounts to 1,282,531 tons, of which 43·7 per cent. is being built in Great Britain and Ireland, and 56·3 per cent. abroad. The quarterly total for the world shows an increase of about 13,000 tons over the figures at the end of March last, and is, with the exception of that for September last, the highest since March, 1932.

In Great Britain and Ireland, 108,122 tons were commenced during the last three months, a decrease of 36,264 tons compared with the corresponding total for the March quarter. During the quarter ended June, 1935, 116,011 tons were launched in Great Britain and Ireland, an increase of 9914 tons as compared with the previous quarter. Similar figures for abroad are 279,311 tons commenced, and 206,974 tons launched, showing, as compared with the previous quarter, an increase of 102,030 tons in the tonnage commenced, and of 33,808 tons in the tonnage launched.

Steam and motor oil tankers under construction in the world amount to 41 vessels of 328,036 tons, of which 9 vessels of 85,000 tons are being built in Germany, 8 vessels of 55,740 tons in Holland, 5 vessels of 42,900 tons in Sweden, 5 vessels of 32,680 tons in Great Britain and Ireland, 3 of 26,603 tons in Japan, 3 of 24,511 tons in the United States of America, and 2 of 18,800 tons in Denmark. Of the 560,321 tons under construction in Great Britain and Ireland at the end of June, 243,996 tons consisted of motor ships, while at the same date the motor ship tonnage being constructed abroad (507,124 tons) was 297,293 tons in excess of that of the steamers.

The vessels being built in the world at the end of June include 5 steamers and 8 motor ships of between 8000 and 10,000 tons each; 6 steamers and 25 motor ships of between 10,000 and 20,000 tons; and 3 steamers and 2 motor ships of 20,000 tons and upwards.

The table respecting marine engines shows that the horse-power of steam engines now being built or being fitted on board amounts to about 572,000 h.p.; this figure includes 46 sets of turbine engines of about 423,000 s.h.p. The horse-power of the steam reciprocating engines—about 149,000 h.p.—amounts to 11·8 per cent. of the total horse-power of marine engines now being built in the world. The figures for oil engines aggregate approximately 698,000 h.p.

Of the merchant shipbuilding in hand throughout the world at the end of June, 929,038 tons, or over 72 per cent., are being built under the inspection of Lloyd's Register. Of this total, 532,348 tons, representing more than 95 per cent. of the tonnage being built there, are under construction in Great Britain and Ireland; while of the tonnage being built abroad, 396,690 tons, or 55 per cent., are being constructed under the inspection of Lloyd's Register.

WATER-HAMMER EXPLOSION.

COMMENTING on the explosion from a cast iron stop valve chest in the turbine steamer "City of Paris," of the Ellerman Line, in December last, Mr. W. T. Williams, the Engineer Surveyor-in-Chief, Board of Trade, says:—

"The danger of water collecting in branch steam pipes connecting pipes under steam with the stop valves of boilers not in use, has previously been emphasised in reports of preliminary and formal inquiries made into explosions from stop valves attached to ships' boilers. The particular explosions referred to, which were too often attended by loss of life, generally occurred at the dead end made by the closed stop valve of straight pipes of some length which were so nearly horizontal that slight alteration in the trim or inclination of the ship was sufficient to induce conditions favourable to setting up water hammer. To obviate the risk in such arrangements, it has been recommended that isolating valves be placed at the junctions of the branches with the main ranges, and had they been fitted and used in this case, the explosion would probably have been avoided. It should be observed, however, that the arrangement of the auxiliary pipes and fittings in the vicinity of the forward boilers would not have presented itself as being particularly liable to water hammer, and the explosion can reasonably be attributed to a combination of adverse circumstances which could hardly have been anticipated and provided for.

"In land installations levels are fixed, and it is not difficult to make arrangements which will with some degree of certainty eliminate any risk of water hammer. In ships, on the other hand, inclinations of the pipes constantly vary, and it is less easy to provide a pipe arrangement which will be kept clear of water, and be correspondingly safe, under all conditions. With this in view, good reasons could be advanced for providing greater security by a more extensive use of cast steel for the chests of stop valves, and other steam fittings. The common use of steel pipes, particularly when solid drawn, has added considerably to the reliability of the pipes themselves, and the security of installations would be further enhanced if the pipes were attached to fittings also made of a ductile material more reliable and capable than cast iron in resisting racking from the thrust of pipes and stresses due to shock.

"It is regretted that two lives were lost as a result of the explosion, but more serious consequences were fortunately averted by the steadiness and skill of the engineer officers, who were admirably supported by the native firemen."

BOOKS RECEIVED.

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BOILER PLANT AT A BELGIAN ZINC WORKS

BABCOCK AND WILCOX, LTD., LONDON AND GLASGOW, ENGINEERS

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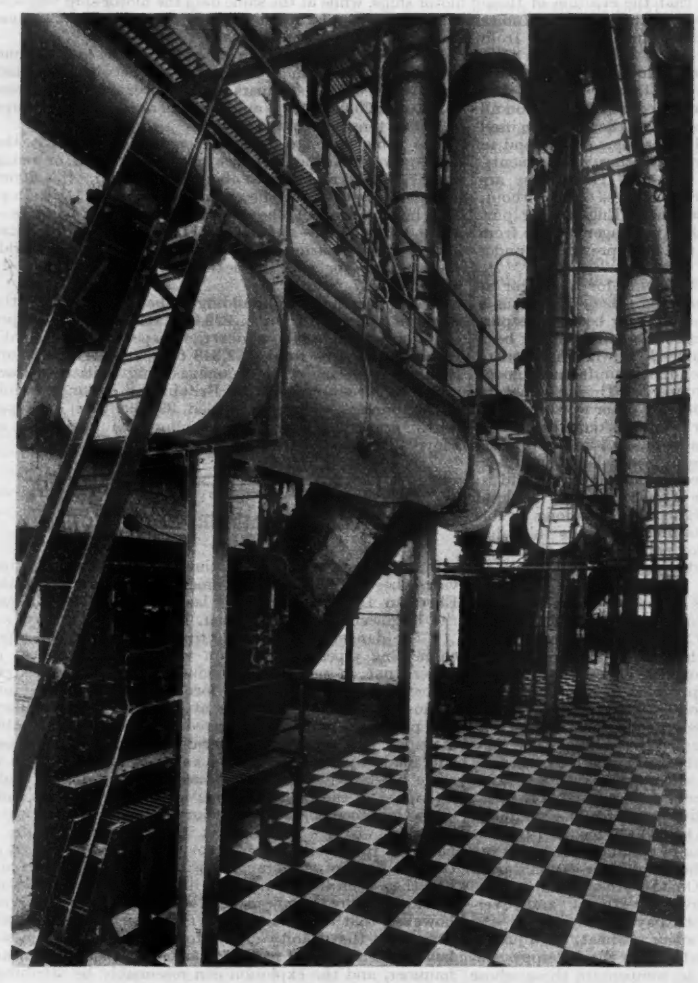

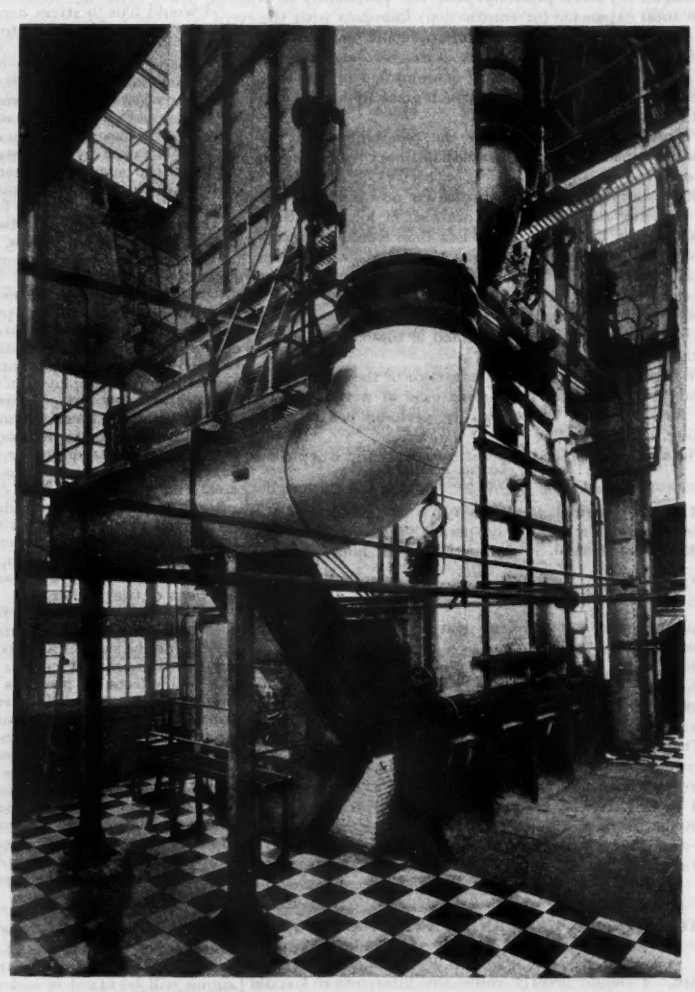

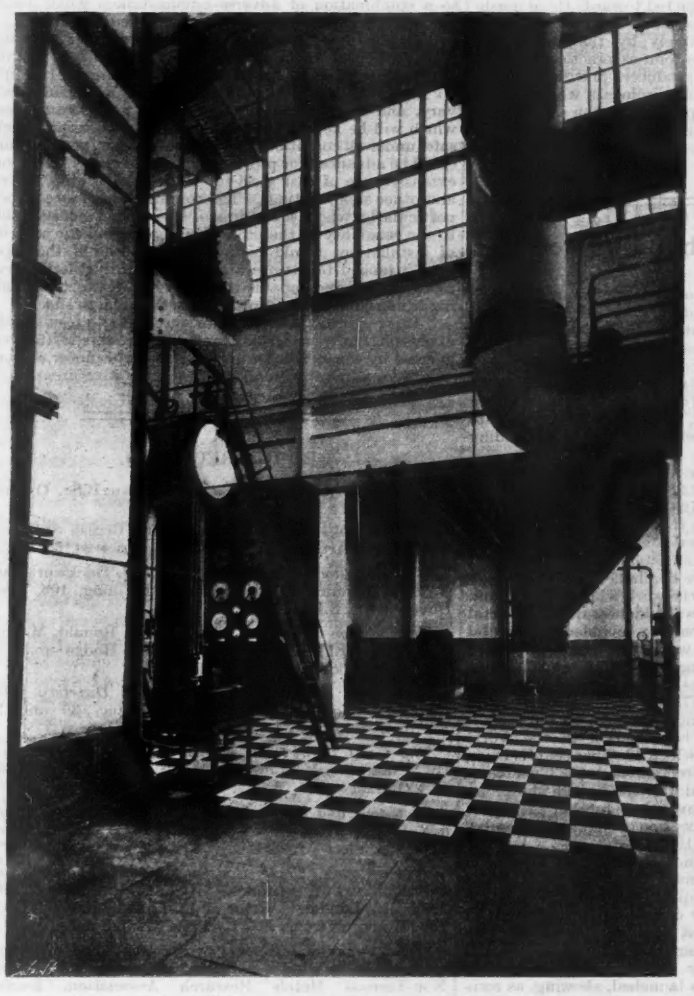

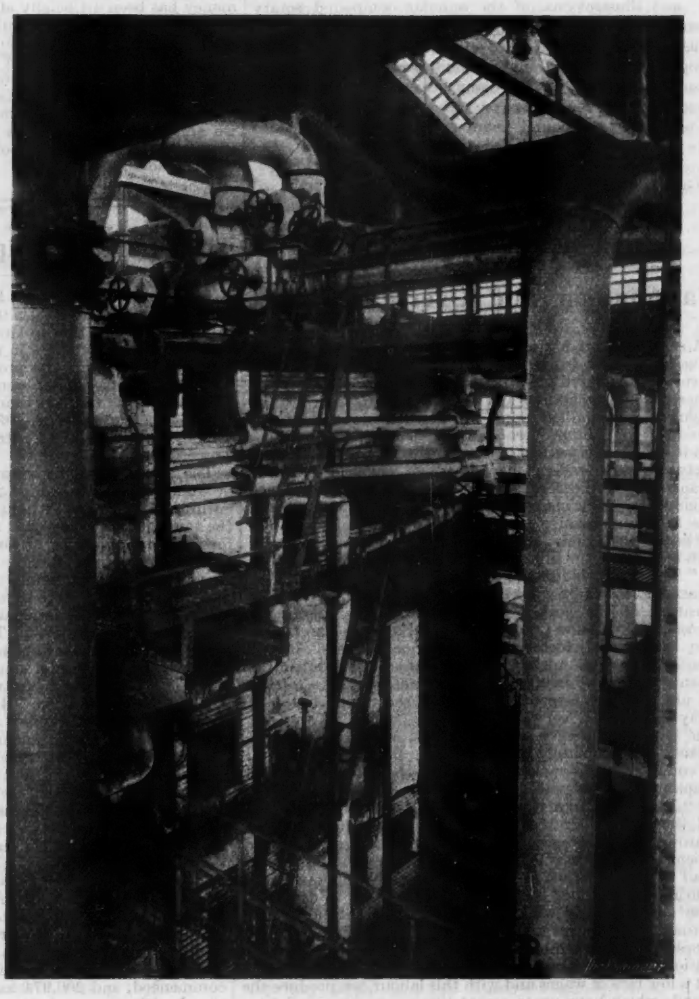

Coal, Oil and Gas Fired Boilers at a Zinc Works.

THE manufacture of zinc and zinc products plays a large part in the industrial life of Belgium, and amongst the various firms engaged in zinc production, the oldest and the most important is the famous "Vieille Montagne" Company. Its origin can be traced back to 1806, when the Abbé Dony was granted a concession to work the great calamine lode at Moresnet on condition that he should succeed in reducing the ore to the metallic state. Prior to that date no metallic zinc had ever been produced on the Continent of Europe, although brass, made by fusing copper along with special "earths," had been known from time immemorial. The Abbé was successful in his experiments, and in 1807 he built a small works at Liége for the treatment of the Moresnet ores. Development, however, was slow, and by 1837, when the Société des Mines et Fonderies de Zinc de la Vieille Montagne was formed to take over the enterprise, the output of zinc had only reached 1830 tons annually. Other companies came into the field later, and by 1913 the annual output of zinc in Belgium amounted to more than 200,000 tons. Of this total the Vieille Montagne Company was by far the largest producer, its output at that period being almost 10 per cent. of the entire world production of zinc. Its demands for ore had long exceeded the capacity of the Belgian deposits, and besides its Belgian properties the company owned mines in France, Algeria, Tunis, Germany, Sweden, Italy, Greece, Mexico, and England. Its activities were, naturally, paralysed by the seizure of Belgium by the German armed forces in 1914, but with the liberation of the country in 1918 the fortunes of the company were restored, and it has once more taken its place as the greatest zinc-producing organisation in the world.

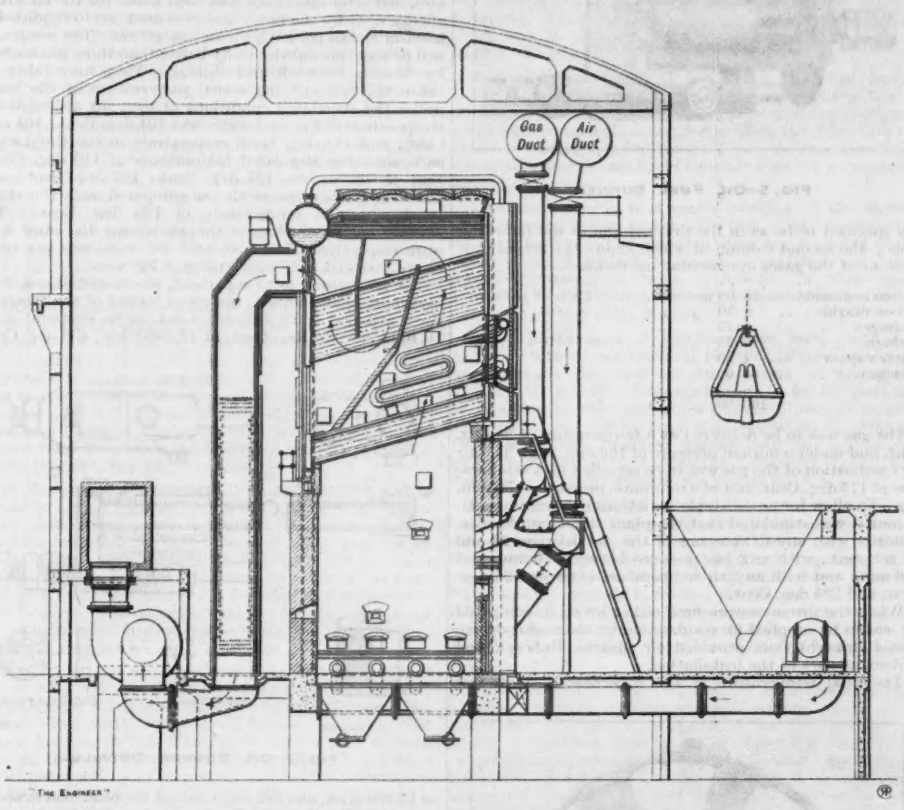

FIG. 1—GENERAL ARRANGEMENT OF BOILER

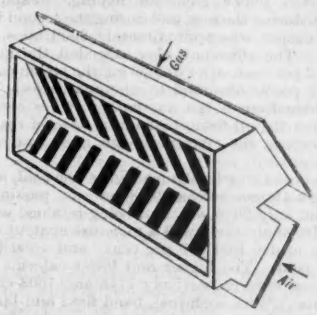

FIG. 2—DIAGRAM OF HUNTER BURNER

With regard both to its processes and equipment, the Vieille Montagne Company has always been in the forefront of the zinc industry, and a recent example of its enterprise has been the installation of a new boiler plant, characterised by some very interesting features, at its works at Baelen, in Belgium. The steam is required for the power supply of the works and the boilers are so designed that each may be fired either by oil, gas, or coal, according to the circumstances prevailing at the time. The fuel gas, it may be mentioned, is a by-product of a process developed by the company for extracting the last traces of zinc, copper, silver, and lead from the slag and residues of the ordinary lead smelting furnaces, these residues having previously been regarded as worse than useless. The method involves the re-smelting of the hitherto waste material along with coke in a special kind of blast-furnace, the metals being vaporised and subsequently precipitated from the gases. The latter have substantially the same composition and calorific value as ordinary blast-furnace gases, and therefore constitute a very useful fuel for the boilers. They are supplied to the latter in a cold state, but the air for their combustion is preheated to a temperature of 125 deg. Cent. by waste heat from the zinc volatilisation furnaces.

The contract for the whole of the boiler plant, comprising three boilers complete with furnaces, gas and oil firing apparatus, forced and induced draught fans, and including all the steam and feed water piping and valves, was entrusted to Babcock and Wilcox, Ltd., of London and Glasgow, who gave strict guarantees as to its performance and efficiency under various outputs and methods of firing. Each of the boilers has a maximum continuous output of 33,000 lb. of steam per hour at a pressure of 570 lb. per square inch and a temperature of 824 deg. Fah. at the outlet of the superheater. The attractiveness of the finished installation, as regards operating conditions and excellence of natural illumination, will be appreciated from the engravings on the opposite page, which are reproductions of untouched photographs taken by ordinary daylight on the firing floor level. The boiler-house floor is of black and white tiles throughout, except for the hand firing areas between the boilers, where iron floor plates are employed. The last engraving gives a view of the upper part of one of the boilers, taken from a gangway on the adjacent boiler, and shows the convenient arrangement of the various operating and isolating valves.

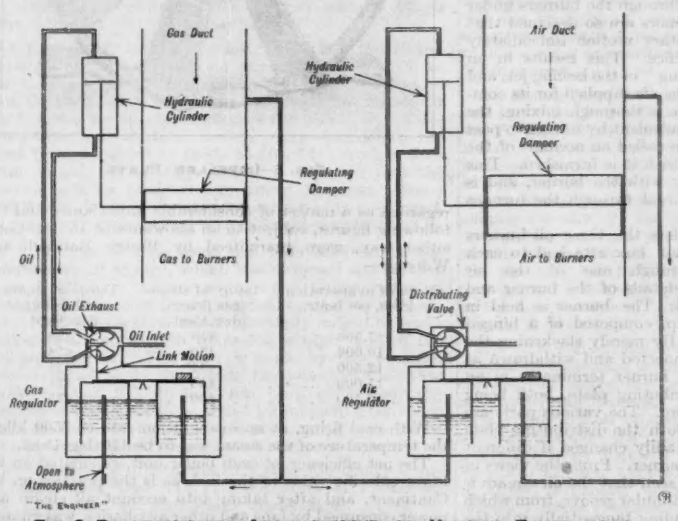

FIG. 3—DIAGRAMMATIC ARRANGEMENT OF HUNTER REGULATORS

The characteristics and principal dimensions of each of the three boilers are summarised in Table I below :—

TABLE I.

Normal hourly evaporation	12,500 kilos.	27,500 lb.
Maximum continuous evaporation per hour	15,000 kilos.	33,000 lb.
Two-hour peak evaporation rate	16,500 kilos.	36,300 lb.
Gauge pressure at superheater outlet	40 kilos.	570 lb.
Steam temperature at superheater outlet	440 deg. C.	824 deg. F.
Feed water temperature to economiser	115 deg. C.	239 deg. F.
Boiler heating surface	510 sq. m.	5490 sq. ft.
Superheater heating surface	160 sq. m.	1720 sq. ft.
Economiser heating surface	385 sq. m.	4144 sq. ft.
Grate area (hand firing)	9·75 sq. m.	105 sq. ft.
Number of boiler tubes	368	368
Length of boiler tubes	5486 mm.	18ft.
Outside diameter of boiler tubes	82 mm.	3·25in.
Number of economiser tubes	660	660
Length of economiser tubes	3·657 m.	12ft.
Outside diameter of economiser tubes	51 mm.	2in.
Number of superheater tubes	90	90
Outside diameter of superheater tubes	51 mm.	2in.
Diameter of boiler drum	1·219 m.	48in.
Length of boiler drum	5334 mm.	17·5ft.
Diameter of stop valve	152 mm.	6in.

The general arrangement of the boilers is illustrated in Fig. 1. As will be seen, the design is of the rear drum marine type with interdeck superheater, and steel tube economiser arranged at the back. From the firing floor to the top of the boiler casing the height is about 46ft., half of this being occupied by the furnace. The centre of the drum is 43ft. above floor level. The boiler tube system comprises sixteen sections, each composed of twenty seamless steel tubes, 82 mm. in outside diameter and 5486 mm. long, expanded into forged steel staggered headers in accordance with Babcock and Wilcox's standard practice. The usual horizontal return tubes provide for the flow of steam and water from the front headers back to the drum. The superheater consists of ninety seamless steel tubes, 51 mm. in diameter, of double hairpin form, expanded into cylindrical headers of forged steel. These headers are out of contact with any hot gases and are readily accessible from the front of the boiler.

The economiser, situated in the vertical downtake of the flue gases behind the boiler, consists of a series of straight steel tubes arranged in horizontal layers, the tubes in one layer being staggered relatively to those above and below them. The tubes are supported by passing through cast iron end plates, in which they are made gas-tight by glands with asbestos packing. One end of each tube is connected to the corresponding end of the tube in the layer above or below by a semi-circular steel bend with flanged and bolted joints. All the bolts are of nickel-chrome steel, combining great strength with a high resistance to corrosion. All the bends and joints are outside the path of the hot gases and can be inspected while the economiser is working. The interior of any tube can be examined and the tube cleaned, if necessary, by the removal of the bend at each end, an operation which does not involve interference with any other part of the economiser. The top and bottom layers of tubes are connected respectively to seamless forged steel collector boxes provided with hand-holes and with flanged branches for the attachment of the feed water connections. The flexible nature of the tube arrangement avoids all difficulties due to differential expansion on account of temperature changes, while the uniformity of the area for water flow precludes the possibility of air or steam pockets under any conditions. The cleaning of the external surfaces of the tubes is done, when necessary, by soot blowers suitably arranged for the purpose.

There are three gas burners and three oil burners, all situated on the front wall of the furnace, the gas burners being placed in a horizontal row above the triangularly arranged oil burners. On the right-hand side of the furnace, as viewed from the front, are the four doors for hand firing, each with an ashpit door beneath. The ashes and clinkers raked out from the furnace are dumped into hoppers below through doors for the purpose in the firing floor. They are taken from the hoppers in rubber-tired hand wagons, for the basement floor is of the same kind, and as perfectly maintained as the floor of the boiler-room itself.

Air for the combustion of the gas and oil is taken from an overhead main, from which a large pipe, terminating in a horizontal portion, descends to the front of each furnace. These air pipes are very prominent in the engravings opposite, and above them, nearer the furnace front, can be seen the gas pipes which are led from an overhead main in a similar fashion. As previously mentioned, the gas is cold, but the air is delivered at a temperature of about 125 deg. Cent. by means of air heaters in the outlet flues of the zinc volatilisation furnaces. The air is supplied at pressure of about 8in. w.g. and the gas at about 6in. w.g., these pressures, of course, being measured before passing through the control valves. The burners are of the Hunter type, illustrated in Fig. 2, in which, as will be seen, the gas and air pass through a number of slots arranged in faces at right angles to each other. Each set of slots is staggered relatively to the other set, the whole arrange-

ment being conducive to rapid and intimate mixing.

The gas and air supply to each boiler is controlled automatically and independently by means of Hunter regulating gear shown diagrammatically in Fig. 3. Considering first the gas regulator, this consists of a tank containing a lever mounted on a central fulcrum and carrying at each end a partially submerged bell. The interior of one bell is connected to the atmosphere, while the interior of the other is subjected to the pressure in the gas mains. An adjustable counterweight on the lever allows any desired balance to be obtained. Should the gas pressure increase or diminish, the gas bell will rise or fall, tipping the lever and operating an oil distributing valve by means of a link connection. The displacement of this valve from its mid-position admits oil pressure to one end of a hydraulic cylinder and connects the other end to the drain. The motion of the piston thus brought about is transmitted to a butterfly valve in the main gas duct, causing the valve to open or close by the amount required to restore the original pressure conditions at the burners. The pressure is thus maintained constant at the value determined by the position of the counterweight, so long as there is sufficient gas in the mains. To alter the amount of gas going to the furnace the operator need not touch the gas valves. All that he has to do is to adjust the position of the counterweight of the controller.

The air regulator is of similar construction to the gas regulator, but has air pressure under one bell and gas pressure under the other. Its counterweight is set so as to allow for the difference between the air and gas pressure, and the regulator will then maintain the correct ratio between gas and air for all variations in the gas pressure. When the operator alters the counterweight of the gas regulator to change the volume of gas being delivered to the furnace, the air regulator automatically varies the volume of air to suit. Should the gas supply fail altogether, the air controller closes the butterfly valve in the air main as far as a limiting stop will permit. The adjustment of the counterweight is permanent and need only be

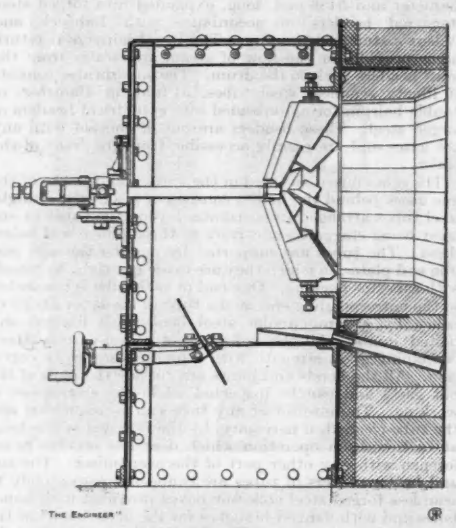

FIG. 4—OIL FUEL BURNER AND AIR BOX

altered if there is a considerable change in the calorific value of the gas or in the temperature of the air being supplied. Any need for adjustment will be indicated by the CO_2 recorder. The oil pressure necessary to operate the hydraulic relay pistons is obtained by means of an overhead tank to which the oil drained from the relay valve is returned continuously by a small rotary pump.

The oil burning apparatus is of Messrs. Babcock and Wilcox's mechanical type, in which the oil, after being filtered and heated, is pumped through the burners under considerable pressure. The burners are so designed that the oil jet is given a rapid rotary motion immediately before its escape from the orifice. This results in an instant breaking up or "atomising" of the issuing jet, and its complete diffusion through the air supplied for its combustion. Still further to ensure a thorough mixing, the entering air is rendered highly turbulent by having to pass through an "impeller plate," so called on account of the formation of the blades with which it is furnished. This plate is mounted concentrically with the burner, and is situated at the entry of the throat through the furnace wall.

In the Vieille Montagne boilers the three oil burners are arranged in a common air box attached to each boiler front. A section through one of the air boxes is given in Fig. 4, and details of the burner and impeller plate in Figs. 5 and 6. The burner is held in position by a quick-release clip, composed of a hinged bridle and a clamping screw. By merely slackening the screw the burner can be disconnected and withdrawn at any time for inspection. The burner terminates in an orifice plate backed by a distributing plate, both being held in position by a screwed cap. The various parts are shown separately in Fig. 7. Both the distributing plate and the orifice plate can be readily changed if different outputs are required from the burner. From the views of the distributing plate it will be seen that the oil stream is forced through six holes into an annular groove, from which it escapes through two slots leading tangentially into the central recess. It thus enters this recess with a rapid rotary movement which persists until the oil has passed through the orifice plate into the furnace. The jet is thus effectively broken up by the centrifugal force into minute drops which burn immediately in the turbulent air.

The pumping unit which delivers the oil under pressure to the burners comprises direct-acting steam-driven force pumps, heaters, and filters, all arranged in duplicate on a common bed-plate. The whole unit is entirely self-contained and is complete with all the valves, gauges, &c., necessary to its operation. It is situated in the basement of the boiler-house, leaving the firing floor free from any encumbrance.

GUARANTEES AND TESTS OF THE BOILERS.

Each of the boilers was guaranteed to be capable of delivering economically 12,500 kilos. of steam per hour at a gauge pressure of 40 kilos. per square centimetre and at a temperature of 440 deg. Cent. at the superheater outlet when supplied with feed water at 115 deg. Cent. They had further to be capable of working continuously at the rate of 15,000 kilos. of steam per hour, and of maintaining an evaporation of 16,500 kilos. per hour for a period of two hours immediately following an indefinite run at the 15,000 kilos. rate. These conditions had to be fulfilled whether the firing was by gas or oil. When hand fired, with coal as fuel, the guaranteed evaporation was 7500 kilos. per hour.

The normal composition of the gas available for firing

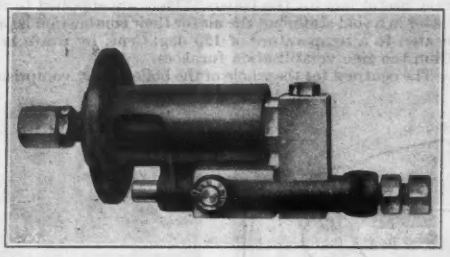

FIG. 5—OIL FUEL BURNER

was specified to be as in the first column of the following table; the second column of which shows the actual proportions of the gases in everyday operation :—

Carbon monoxide	25·00 per cent.		28 to 29 per cent.
Carbon dioxide	6·50 ,, ,,		4 to 5 ,, ,,
Hydrogen	0·25 ,, ,,		2 to 3 ,, ,,
Methane	0·25 ,, ,,		0·2 to 0·4 ,, ,,
Water vapour	4·00 ,, ,,		
Nitrogen	64·00 ,, ,,		
	100·00 ,, ,,		

The gas was to be delivered at a temperature of 20 deg. Cent. and under a normal pressure of 100 mm. w.g. The air for combustion of the gas was to be supplied at a temperature of 175 deg. Cent. and at a minimum pressure of 50 mm. w.g. To allow for unavoidable variations in operating conditions it was stipulated that the plant should work satisfactorily with any CO content of the gas between 23 and 27 per cent., with any gas pressure between 70 mm. and 130 mm., and with any air temperature between 125 deg. Cent. and 225 deg. Cent.

When the furnaces were fired either by oil or coal, cold air was to be supplied for combustion by the motor-driven forced draught fans provided by Messrs. Babcock and Wilcox as part of the installation.

The final temperature of the superheated steam was

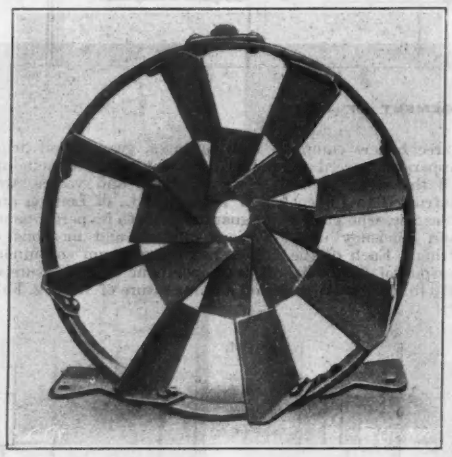

FIG. 6—IMPELLER PLATE

regarded as a matter of considerable importance, and the following figures, subject to an allowance of 15 deg. Cent. either way, were guaranteed by Messrs. Babcock and Wilcox :—

Rate of evaporation, kilos. per hour.	Temp. of steam (gas firing), deg. Cent.	Temp. of steam (oil firing), deg. Cent.
7,500	415	398
10,000	430	414
12,500	441	424
15,000	448	431
16,500	450	433

With coal firing, at an evaporation rate of 7500 kilos., the temperature of the steam was to be 420 deg. Cent.

The net efficiency of each boiler unit, calculated on the lower calorific value of the fuel, as is the practice on the Continent, and after taking into account all steam and power consumed by fans and other auxiliaries, was guaranteed to be 87 per cent. with oil firing at an output of 12,500 kilos. of steam per hour. At the same load an efficiency of 82 per cent. was guaranteed with gas firing, and efficiencies of 81 per cent. at outputs of both 15,000 and 9000 kilos. per hour. These also were all net efficiencies and were to be obtained with air for combustion supplied at a temperature of 175 deg. Cent. When the boiler was hand fired with coal as fuel the efficiency was to be 77 per cent. at an output of 7500 kilos. of steam per hour.

The testing of the boilers was entrusted by the Vieille Montagne Company to the Association Vinçotte, of Brussels, a firm whose reputation and experience in such work are second to none on the Continent. As all three units were identical in design and construction, it was decided to carry out exhaustive tests on one boiler only. These tests occupied six days and covered all methods of firing, every possible precaution being taken to ensure accuracy. The quantities of water, fuel oil, and coal were determined by weighing, while the amount of gas consumed and of the hot air used for its combustion were measured by nozzles approved by the V.D.I. for such tests. The calorific value of the gas was measured by a Junkers calorimeter, calibrated both before and after use. The flue gas analyses were carried out by Orsat apparatus, and the usual optical and resistance pyrometers were employed for measuring the furnace and other temperatures.

The report on the tests which was submitted by the Association Vinçotte is of so detailed a nature and contains so many pages of tabulated figures that it is impossible for us to attempt to do more than summarise the principal results obtained. Tests carried out with gas firing at evaporations of 10,100 kilos., 12,500 kilos. and 15,400 kilos. per hour gave net efficiencies of 85·3, 83·7, and 82·5 per cent. respectively. These figures of efficiency are based on the lower calorific value of the gas and were obtained after allowance had been made for the electrical energy used by the fan, which was assumed to require 4·5 kilos. of steam per kWh for its generation. The results, as will be seen, are substantially better than those guaranteed by Messrs. Babcock and Wilcox. They may fairly be taken to represent the actual performance of the boiler under the stipulated conditions of test, for although the temperature of the feed water was 104 deg. Cent., 108 deg. Cent., and 111 deg. Cent. respectively in the three tests, as against the stipulated temperature of 115 deg. Cent., that of the air was 127 deg. Cent., 102 deg. Cent., and 135 deg. Cent. respectively, as compared with the stipulated minimum temperature of 125 deg. Cent. The average calorific values of the gas during the same tests were respectively 928, 890, and 959·9 calories per cubic metre, reduced to 0 deg. Cent. and 760 mm.

The guarantees as to superheat, mentioned above, were also more than fulfilled, the mean values of the temperatures attained being 420 deg. Cent. at an evaporation of 10,100 kilos, 433 deg. Cent. at 12,500 kilos., 439 deg. Cent.

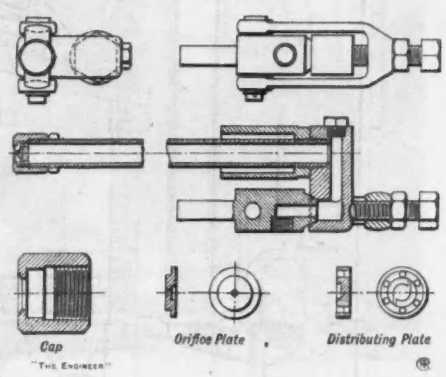

FIG. 7—OIL BURNER DETAILS

at 15,400 kilos, and 442 deg. Cent. at the peak load evaporation of 16,800 kilos. The maximum temperature permitted under the terms of the contract was 465 deg. Cent. and this was never reached.

The guaranteed efficiency of 87 per cent., at an evaporation of 12,500 kilos. per hour when the boiler was being fired with fuel oil, was also realised on test, after deduction had been made of the steam required for heating and pumping the oil and after allowance for the power required by the fans. The oil used for the test liquified at 34 deg. Cent. and had a closed flash temperature of 114 deg. Cent. Its analysis showed 86·5 per cent. of carbon and 12·6 per cent. of hydrogen, the higher and lower calorific values being respectively 10,585 and 9910 calories per kilogramme.

Under coal firing conditions an evaporation of 7500 kilos. per hour was guaranteed with an efficiency of 77 per cent. Actually the boiler gave an average evaporation of 8400 kilos. during the test, and during the second half of the time the output was approximately 9000 kilos. of steam per hour. The efficiency also exceeded the guarantees, being 80·2 per cent. after deducting the steam corresponding to the power absorbed by the auxiliaries. Making a further deduction of the amount of steam consumed in maintaining the oil firing plant in a state of readiness for instant service, the efficiency even then was as high as 78·8 per cent.

The fuel used was Limbourg-Meuse fine coal, all capable of passing a 10 mm. screen, 28·8 per cent. passing a 1 mm. screen, and only 20·5 per cent. being retained on a 5 mm. screen. Its analysis showed a moisture content of 9·1 per cent., ash in dry fuel 9·0 per cent., and volatile matters 17·8 per cent. The higher and lower calorific values of the dry coal were respectively 7746 and 7503 calories per kilogramme. With such fuel, hand fired and burned with forced and induced draught, it was possible to maintain an average of nearly 12·5 per cent. of CO_2 in the flue gases at the boiler exit. As showing what can be done with good hand firing, it is stated in the report that at times the percentage of CO_2 was as high as 16 and 17 per cent., without any appreciable amount of CO being present in the gases. This state of affairs existed when the fuel bed was made perfectly regular over the whole surface of the grate by means of the slice.

A NEW barge for the Commander-in-Chief of the Mediterranean Fleet underwent official trials off Southampton on Monday, July 8th, and was delivered at Portsmouth. It has three 100 h.p. engines, with a designed speed of 30 knots, and was built by the British Power Boat Company, Ltd., to the designs of Mr. H. Scott-Paine.

Rail and Road.

WE consider it fitting, in view of our leader of July 5th on the noise problem, to report that the L.N.E.R. has undertaken a campaign to reduce the noises in stations at which night trains call. Barrows are to have rubber tires, drivers are not to allow the safety valves to blow off steam needlessly; except in emergency the locomotive whistle is not to be used, and drivers are to stop and start their trains quietly.

THE London, Midland and Scottish Railway carried out a special twenty-four hours' test, concluding at midnight on Tuesday, July 9th, of the timekeeping of every passenger train throughout the system in England, Scotland, and Wales. The test, which dealt with 14,000 trains, showed that 98·2 per cent. of punctuality was achieved for the whole line. The long-distance expresses averaged 98·6 per cent. This is the first test on this system to be carried out during the busy summer season.

THE Automobile Association has completed its 2000-mile survey of the International Highway from London to Istanbul, and the party of six British motorists who in eight days have driven through the nine countries connected by the road are on their way back to England. A full report on progress made in the construction of the several national sections of the road will be submitted by the A.A. to a representative conference which the Hungarian Government will convene at Budapest in September.

AN appeal was made in *The Times* of July 4th for some charitably disposed person or persons to buy the Lynton and Barnstaple Railway of 1ft. 11½in. gauge, which was opened in 1898 as a result of the efforts of Sir George Newnes. It passed into the possession of the London and South-Western and so is now part of the Southern Railway. The cost to build was approximately £130,000, and the L. and S.W got it for £39,000. As the loss on working is now £5000 a year the Southern is closing it down at the end of September.

DAZZLING headlights on motor vehicles are not only a common cause of accidents, but are also a source of inconvenience to all road users. New regulations provide that from April 19th, 1936, the beam from any electric lamp exceeding 6 watts in power fitted to a motor vehicle shall either be permanently deflected, or be capable of deflection to such an extent that it cannot dazzle any person standing on the same horizontal plane as the vehicle at a greater distance than 25ft. from the lamp and whose eye level is not less than 3ft. 6in. above that plane.

THE Ministry of Transport railway statistics for March, referred to herein on July 5th, also contained the figures for the three months ended March 31st. Those showed that, compared with the first quarter of 1934, there was an increase of 1·7 per cent. in the number of passenger journeys, a decrease of 4·8 per cent. in the receipts from passengers, and a decrease of 3·1 per cent. in the passenger traffic receipts. The tonnage of freight dropped by 1·6 per cent., of which 2·3 per cent. was in general merchandise, and freight receipts fell by 2·3 per cent.

PRESSURE on our space, in reviewing on page 5 of our issue of July 5th, the Ministry of Transport reports on three passenger train derailments prevented us from dealing with two other matters mentioned therein. One was that Colonel Trench, in the Hazelwood report, and Colonel Mount, in that on Ashton-under-Hill, urged the importance of chief permanent way inspectors and district permanent way inspectors acting up to the rule as to obtaining information of the condition of the track by riding on the foot-plate. The other point relating to the classification of lines led Colonel Mount to remark that under the L.M.S. Company's progressive policy of scrapping older types of engines, the building of new, heavier, and speedier units was making rapid strides. He suggested, therefore, that the whole question of the classification of branch lines, not only in respect of bridge loading, but of track fitness for speed in relation to types of engines, required review.

THE reasons Colonel Mount had, no doubt, in view, when he made the remark in his King's Langley accident report, mentioned on our Seven-day Journal page on July 12th, that searchlights on engines, in main line operation, would not be desirable from a safety point of view, were that they would dazzle the sight of a driver approaching from the opposite direction; they would impair the driver's own view of what was out of the range of light given by the searchlight, and whilst they would show up the position of the arms of semaphore signals they would blind the range of the increasing number of colour-light signals. Electric headlights are of use in America, India, South Africa, &c., as they reveal the presence on the line of strayed horses, cattle, &c., but as British railways are fenced off such obstructions rarely occur. Colonel Mount also referred to the fact that steps are having to be taken to-day to safeguard the view of enginemen from interference by extraneous road light signals and by street and sign lighting. In the latter connection we would refer to the action taken at Deptford by the Southern Railway, as related herein on February 8th last.

IN contrast with many other countries, and with the United States in particular, there are, and always have been, very few cases of two railways crossing each other's tracks on the level in Great Britain. Now that the L. and N.W. and the Midland are part of the L.M.S. the crossing at Bedford comes out of the list and the G.N. and G.C., being members of the L.N.E.R., excludes the crossing at Retford. Actually there are now only two cases: the L.N.E.R. over the L.M.S.at Newark, and the Somerset and Dorset over the Great Western at Highbridge. There was, however, until Carlisle Citadel Station was rearranged in 1875, to admit the Midland Company's Settle and Carlisle line, a level crossing at St. Nicholas crossing, on the south side of that station, where the Lancaster and Carlisle crossed the goods lines of the North-Eastern Company's Newcastle and Carlisle. Sixty-five years ago on July 10th there was one of the still rarer cases of collision at such crossings. The driver of a goods train on the latter line had reason to be absent from the footplate and whilst in the fireman's charge the train moved forward against the signals and collided with the up mail. Five passengers were killed.

Miscellanea.

A LARGE part of the Vaal River has been diverted for the purpose of winning diamonds from the rich gravel in the river bed.

AT the invitation of the Birmingham and District Section, it has been decided to hold the next Congress of the Institute of Transport at Birmingham from May 20th to 23rd, 1936.

THE establishment of a tin smelting industry in the Belgian Congo, which was begun some time ago, is now so far advanced that the recently erected smelting works will shortly come into operation.

IT is announced that the Lord President of the Council has appointed Mr. Bernard Smith, Sc.D., F.R.S., at present Assistant to the Director in England, to be Director of the Geological Survey and Museum as from October 1st next on the retirement from that office of Sir John Flett, F.R.S.

ACCORDING to the *Iron and Coal Trades Review*, a new abrasive styled "Norbite," Norton Boron Carbide, B_4C, has been produced in the laboratories of the Norton Company. It can be supplied in grain, powder, or moulded form, and is claimed to be the hardest manufactured abrasive known.

AT a recent meeting of the Forth and Tay Bridge Committee, it was stated that as regards the Tay Bridge all necessary boring operations had been completed, and plans were sufficiently advanced to allow the Town Council to go to Parliament for the necessary powers if suitable financial arrangements could be made with other interested local authorities.

THE result of the first year's working of the Mersey Tunnel, which was opened on July 18th, 1934, has exceeded all expectations. The actual returns are expected to be close upon 3,000,000 toll-paying vehicles and over 3,600,000 passengers, with a revenue of close upon £250,000. A report is now being prepared on the use of the lower portion of the tunnel.

SOME 18,500 tons of material have been excavated and 4000 tons of concrete and 110 tons of steel reinforcement already put into the foundations on which the 51,000 kW B.T.H. turbo-alternator is to be installed at Kearsley by the Lancashire Electric Power Company. This plant will be brought into operation in August, 1936, when the Kearsley station will be the largest generating station in Lancashire. Another 51,000 kW machine is to be installed by the winter of 1938.

DETINNING operations are much simplified and rendered less dangerous by using acetic acid in place of chlorine, a process evolved by Mr. Dekker, of Delft. By heating the tin-plate in a closed chamber containing acetic acid vapour, the tin is attacked and a white layer of small water-soluble crystals is formed on the surface, the iron base not being attacked. The acid reacts with the tin at ordinary temperatures, although heating is desirable to speed up the reaction. Formic acid may be used in place of acetic acid.

A PROPOSED American standard for large rivets, of ½in. nominal diameter and larger, has recently been completed by Sub-Committee No. 1 of the Sectional Committee on the Standardisation of Bolt, Nut and Rivet Proportions sponsored by the American Society of Mechanical Engineers and the Society of Automotive Engineers. This proposed standard represents the second revision of an earlier proposed American standard for large rivets, dated October, 1928, and is now being distributed to industry for criticism and comment.

SOLID petrol was recently exhibited at the Guggenheim School of Aeronautics at New York University. It has been developed as a result of experiments begun in 1919 by Dr. Adolph Prussin, and is a reddish jelly-like substance. In a small test engine developing 2·26 h.p. at 1085 r.p.m. the consumption of fuel was 0·71 lb. per horse-power hour. Liquid petrol in the same engine produced 2·41 h.p. at 1125 r.p.m., but the consumption of fuel was 0·92 lb. per horse-power hour. The new fuel is not high in cost and it can be stored without danger of fire, and is, it is claimed, easy to handle.

AT its meeting held on Friday, July 12th, the Metropolitan Water Board decided to entrust the work of constructing a new London reservoir in the Lee Valley to John Mowlem and Co., Ltd. Sir George Handover presided over the special meeting of the Works and Stores Committee, and thirteen tenders were considered, the lowest being accepted at £682,155 19s. 7d. Work will be begun almost immediately, and it is expected that the reservoir will be completed in about 3½ years. Some 2,500,000 cubic yards of material will have to be excavated, and the new contract will give considerable employment.

A NEW type of pipe joint has been adopted in the Lausanne water scheme, which was designed and laid by Sulzer Brothers. In one section the Sulzer patented system of testing-muff joints, welded together on site, are used. Each pipe section has a spherically bulged enlarged opening at one end which takes the straight end of the next pipe section. The joint is made by two separate circumferential welds, one inside the pipe and the other outside. After the welding has been completed, the tightness of the joint can be tested by subjecting the space under the bulge by hydraulic pressure, a test pressure of about 1½ times the working pressure being employed.

THE Official Returns rendered to the Electricity Commissioners show that 1147 million units of electricity were generated by authorised undertakers in Great Britain during the month of June, 1935, as compared with the revised figure of 1049 million units in the corresponding month of 1934, representing an increase of 98 million units, or 9·3 per cent. The number of working days in the month (i.e., excluding Sundays and Bank Holidays) was twenty-four as against twenty-six last year. During the first six months of 1935 up to the end of June, the total amount of electricity generated by authorised undertakers was 8502 million units, as compared with the revised figure of 7632 million units for the corresponding period of 1934, representing an increase of 870 million units, or 11·4 per cent.

Air and Water.

ALDERNEY, in the Channel Islands, is to be provided with a direct transport service with England and will become the first stage on the Jersey Airways route.

A TRI-MOTOR Ford aeroplane, which went into service in 1927, and is said to have been the first commercial aircraft to cross the Rocky Mountains, has found a place in the Ford Museum at Dearborn, Michigan.

PRELIMINARY plans for a Tasman Sea air service under the sole control of the Commonwealth and New Zealand Governments have been submitted by Sir Charles Kingsford Smith to Mr. Parkhill, the Commonwealth Defence Minister, who has agreed to them in principle.

THE idle vessels now laid up on the river Tyne number sixty-two, and total 128,396 tons. The present figure is three below that of December, 1934, the previous lowest figure. Three years ago no less than 180 idle ships were berthed on the Tyne, aggregating 391,000 tons.

WITH a view to establishing a Transatlantic seaplane service, the French Air Ministry is sending a deputation of experts to the Azores and the Bermudas in order to study the possibility of finding large areas of smooth water suitable for arrival and departure of seaplanes.

IT is announced that the Hawker Siddeley Aircraft Company, Ltd., has been formed to acquire all or part of the Armstrong Siddeley Development Company, Ltd., and Hawker Aircraft, Ltd., and to carry on the business of manufacturers, designers, and constructors of and dealers in aircraft.

THE new French submarine "Tonnant," with engines of 8600 s.h.p., has established an international record for submarines of its type by reaching a speed of over 21 knots in official tests. The only faster submarine is the British "Thames," with 10,000 s.h.p., which has achieved 22½ knots.

THE Vice-Chancellor of Cambridge University announces that he has received a letter from Sir John D. Siddeley offering to the University the sum of £10,000, spread over a period of seven years, for the purpose of helping the development of aeronautical research, in order to assist the work of Professor Melvill Jones and his associates in the Sub-Department of Aeronautics in the University.

THE Nippon Yusen Kaisha, of Tokyo, has recently contracted with the Mitsubishi Jukogyo Kabushiki Kaisha for the construction of two cargo motorships of 7450 gross tons, propelled by 8000 b.h.p. Mitsubishi-Sulzer double-acting, two-stroke engines, designed for a sea speed of about 16 knots, and a trial speed of 19 knots. They will be employed on a monthly service between Yokohama and Liverpool.

THE German airship "Graf Zeppelin" has now begun its fortnightly trips to Pernambuco and Rio de Janeiro. The last summer "sailing" from Germany will be made on October 21st. The Syndicato Condor Limitada Company has arranged to carry passengers from Rio on to Buenos Aires in Junkers aeroplanes. A fortnightly Zeppelin service from Europe to New York, increased later to a weekly service, is eventually contemplated by the Zeppelin Company.

AT a meeting held on Wednesday, July 3rd, the Liverpool City Council approved the sale of land adjoining the airport at Speke for an aircraft factory to the British International Aircraft Distributing Company, Ltd., which is associated with the Bellanca Aircraft Corporation of America. The contract stipulates that an aircraft factory, to cost not less than £65,000, must be erected within twelve months. It is expected that half-a-dozen machines will eventually be turned out each week.

NAVY Week at Chatham is being held this year on August 3rd and 5th to 10th. Warships and submarines in the dockyard will be open to visitors and there will be many displays and side-shows. The most dramatic incidents will be a battle between a "Q" boat and a real submarine, in which the submarine is "sunk"; an action between a flight of aeroplanes and a cruiser; and a representation of the historic attack on Zeebrugge. Exhibitions will also be given of deep-sea divers at work, the Davis submerged escape apparatus, by which men may escape from a sunken submarine, and the firing of torpedoes and depth charges.

AN unusual accident took place near to the Schiphol aerodrome at Amsterdam on Sunday, July 14th, when the K.L.M. Royal Dutch air liner from Amsterdam to Malmö, Sweden, carrying a crew of five and fifteen passengers crashed and took fire. Two British passengers and five of the crew lost their lives. According to an official statement issued by the K.L.M. Company, in making the take-off the two port engines decreased in revolutions, and the machine made a forced landing outside the aerodrome, during which it ran into a dike, was wrecked, and took fire. The aeroplane was of the four-engined "Fokker" type, which is normally employed in the Malmö service. An inquiry into the cause of the disaster is to be held.

OWING to the expansion of the Royal Air Force, a large number of tradesmen are required for service in a civilian capacity for instruction work in fitting, metal rigging, armament, and wireless. They will be employed at the appropriate schools of instruction. These appointments will be made over the period of the next twelve months, a number being required immediately. The School of Technical Training (Apprentices) at Halton, Bucks., will be largely expanded in order to deal with a greatly increased intake of aircraft apprentices, and a new school will be temporarily opened at Henlow, Beds., for the special training of the new classes of R.A.F. flight mechanic and flight rigger who are required in large numbers for immediate service. The Electrical and Wireless School at Cranwell, the Air Armament School at Eastchurch, and the School of Technical Training at Manston will also have to handle a greatly increased entry of wireless operators, armourers, fitters, &c. Applications should be addressed to the Commanding Officer, R.A.F. Reception Depôt, West Drayton, Middlesex, who will furnish full particulars and arrange for the necessary trade test at West Drayton before appointment.

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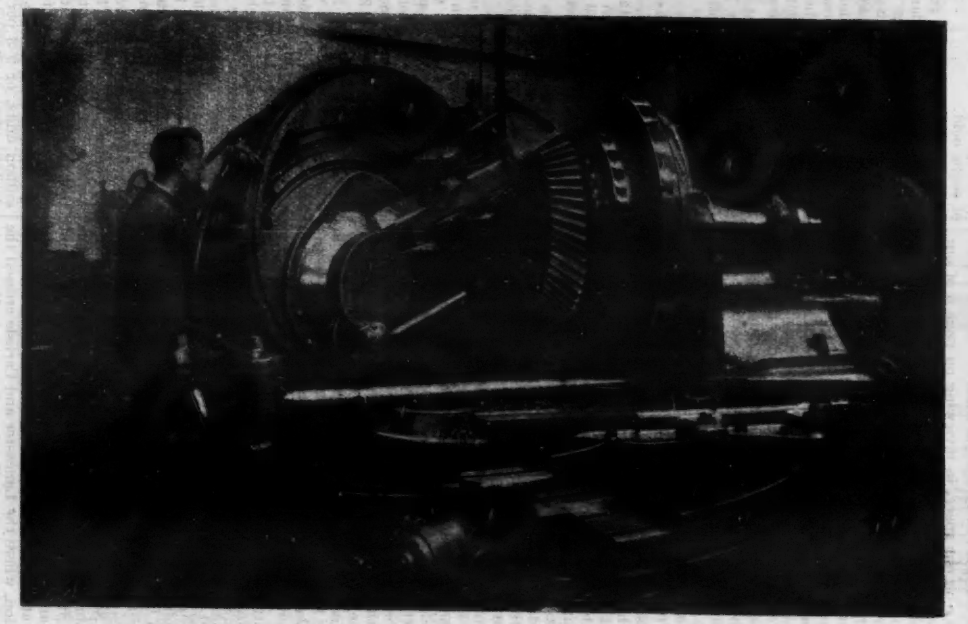
(*For description see page 69.*)

ABOVE:—THE HARDENING SHOP
BELOW:—60IN. GLEASON BEVEL CUTTING MACHINE



ABOVE:—THE LABORATORIES
BELOW:—CUTTING A DOUBLE HELICAL GEAR

The Engineer

JULY 19, 1935.

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NOTICES TO READERS.

**** *If any Subscriber abroad should receive* THE ENGINEER *in an imperfect or mutilated condition, he will oblige by giving prompt information of the fact to the Publisher, with the name of the Agent through whom the paper is obtained. Such inconvenience, if suffered, can be remedied by obtaining the paper direct from this office.*

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CHANGES OF ADDRESS.

**** *Will subscribers please note that in all advices regarding changes of address it is necessary to have* **both the old and new addresses,** *as our lists are kept alphabetically by towns. Advices of this nature should reach us by the first post Wednesday morning prior to the alteration.*

THE JUBILEE NAVAL REVIEW.

THE largest naval force seen in home waters for many years assembled at Spithead during the weekend for the Silver Jubilee Naval Review by H.M. the King. It comprises 157 vessels drawn from the Mediterranean, Home, and Reserve Fleets, and is manned by approximately 48,000 officers and men. Viewed in the beautiful and historic setting of Spithead roadstead, this vast concourse of ships presents a most impressive spectacle, amplified by the presence of twenty-eight vessels of the mercantile marine and fishing fleets. This display occurs at a time when the thoughts of the nation are turning once more to problems of naval defence. Almost everywhere except in this country large programmes of naval construction are actively in train or about to be launched. The United States is pressing forward with the Vinson plan, which aims at bringing the fleet up to full Treaty strength in every category of vessel. The U.S. Naval Budget for the new financial year is but little short of £100,000,000, and is by far the largest ever voted in times of peace. Japan, too, is building steadily to implement her claim to a much larger proportion of fighting tonnage than she has hitherto possessed. Her current expenditure on sea, land, and air armaments is equivalent to almost one-half of the National Budget. France, which has reacted unfavourably to the Anglo-German Naval Agreement, contemplates large additions to her fleet, the relative strength of which has been doubled in the last six years. As our French correspondent reported recently, this year will see the launching or completion of six powerful cruisers, well armoured, mounting nine 6·1in. guns, and capable of speeds up to 33 knots. Huge flotilla leaders, whose average of 2500 tons displacement puts them in the light cruiser category, are built or building to the number of thirty-two. France, in fact, will shortly have fifty post-war cruisers from 10,000 tons downward. In the heavier types she is building the "Dunkerque" and "Strasbourg," battle cruisers of 26,500 tons, and two, if not three, 35,000-ton battleships have been authorised for laying down this year and next. Finally, the French Navy possesses about 100 effective submarines, a flotilla unmatched by any other Power. Italy is another determined competitor in the naval race. She is at work on a pair of 35,000-ton ships of the battle cruiser class and is steadily adding to her lighter naval forces, including submarines. Even the Russian naval dockyards are in full activity. From Moscow comes the announcement that since 1931 the Soviet submarine arm has increased by 435 per cent. In addition, there are now on the stocks, or soon to be laid down, six cruisers, six large destroyers, and twenty-five submarines.

A further and most important development in the general naval situation occurred last week, when details of the German shipbuilding programme were released in Berlin. Although such a programme was not unexpected, and had, indeed, become inevitable, certain items in it came as an unpleasant surprise to British public opinion. The new vessels already in hand or to be laid down this year are: Two battleships of 26,000 tons each, with 11in. guns; two cruisers of 10,000 tons each, with 8in. guns; sixteen destroyers of 1625 tons each, with 5in. guns; twenty submarines of 250 tons, six of 500 tons, and two of 750 tons each. In all, therefore, twenty-eight German submarines will be afloat or under construction before the end of the year. The number is indicative of Germany's unshaken faith in the potency of this weapon, which, however, she has solemnly bound herself never again to use in an unlawful manner. It seems clear that the twenty small boats are intended to serve primarily as training units. This first submarine programme will absorb a very large proportion of the tonnage ratio in this category to which Germany is entitled under the Anglo-German agreement. From this may be inferred her intention to build up to the full 35 : 100 in all types with the least possible delay, and especially in the submarine category in which she is allowed the higher ratio of 45. According to credible report, the two "battleships" are, in fact, battle cruisers with a speed above 30 knots and an armament of twelve 11in. guns. They are openly spoken of in Germany as a reply to the French "Dunkerque" class, of approximately the same tonnage, but with an armament of eight 13in. guns. Germany, it will be observed, adheres to her traditional policy of mounting the lightest gun consistent with long-range, armour-piercing requirements, preferring rapidity, and therefore volume, of fire to a smaller number of heavier guns. These vessels, it seems, are to be driven by steam turbines. The oil-engine plant installed in the three "pocket battleships" of the "Deutschland" class may have given entire satisfaction, but apparently that type of prime mover is not considered to be sufficiently developed for application to the new battle cruisers. That Germany should have elected to build two 10,000-ton cruisers, with a battery of 8in. guns, is rather surprising. Except in the United States this type of vessel, which owes its genesis to the Washington Conference, has fallen into disrepute on account of its dangerous want of protection. It is probably a safe guess that in the German version armour defence will not be neglected, even if it involves some sacrifice of speed. The details of the sixteen destroyers, like those of the battle cruisers, point strongly to France as the Power which the German naval authorities had in mind when they drew up this programme. Reference is made above to the French "flotilla leaders," and it is evident that these German destroyers, with their generous displacement and formidable guns, are designed as counterweights to a specific type, which is more likely to be French than any other. We in this country cannot justly complain if Germany, within the limits of her agreement with us, develops tactical naval ideas of her own and gives them concrete form. But neither can we remain indifferent. Already we are facing the fact that Germany, within two or three years, will have at sea battle cruisers which in speed and fighting power are equalled by only one ship in the whole of the Navy—H.M.S. "Hood"—that she will possess destroyers individually superior to our best types, and a strong flotilla of submarines including a number of ocean-going units. In all of this there may be no grounds for alarm, but there is certainly cause for vigilance. Germany's rearmament at sea is the last, and not the least, of the many new factors of recent origin which are driving Great Britain, much against her will, to strengthen her own defence forces. What appears to be an adequate plan of Air Force expansion is already well under way. It must now be the turn of the Navy.

How much there is to be done will be only too obvious to those who turn a professional eye on the Fleet at Spithead. Of the eleven capital ships present only the "Nelson" and "Rodney" are of post-war vintage, and even they were put afloat nearly ten years ago. The others are maintained in a seaworthy condition only by periodical refits at great expense. At any given moment at least three out of our total of fifteen capital units are absent in dockyard, undergoing "large repairs." The cruisers at the Review make a brave showing, but only because a number of obsolete ships from the Reserve Fleet have been furbished up and manned for the occasion. Actually, no more than eight of those present are of post-war construction. As with the cruisers, the Reserve Fleet destroyers would be of dubious value in a national emergency, while the merest novice in naval affairs will be able to assess the fighting value of the auxiliaries, such as sloops and minesweepers, which help to swell the numerical strength of the Fleet at Spithead. The Jubilee Review is, therefore, even more an exhibition of what we lack than of what we have. Properly regarded, our present Fleet, with its huge proportion of worn-out material, is no more than the nucleus of the Fleet which we must at all costs have ready in the critical years to come. Conditions to-day bear a certain resemblance to those of the penultimate decade of the last century, when the gaps revealed in what was then, without question, our first line of defence shocked the nation and led to the passing of the Naval Defence Act of 1889. If anything, however, the outlook is even more serious. Naval competition in those days was localised in European waters; to-day, it is literally world-wide. Our task is to build up a fleet powerful enough to provide a reasonable margin of security for British interests in Home Waters, the Mediterranean, and the Far East. The cost must needs be heavy, but, as has already been shown by the almost unanimous approval of the expensive programme of Air Force expansion, the country will shirk no sacrifice in the cause of security. The Government, it is understood, has determined to repudiate the arbitrary limit imposed on our cruiser strength by the London Treaty. Unless the "escalator" clause is invoked, we must, of course, be bound by that treaty until the end of next year. After that, however, it is proposed to increase the number of cruisers from fifty to at least sixty, and proportionately to enlarge the destroyer establishment and other light forces. There is no hope whatever of reaching a new, multilateral agreement which will effect any substantial reduction in foreign fleets. A large building programme for our own Navy is, therefore, inevitable, and in view of the number of capital ships now building on the Continent—no less than twelve have been laid down or authorised by France, Italy, and Germany together—we must prepare for the construction of battleships, as well as of cruisers and smaller types. It is further to be noted that the majority of the capital units building abroad will displace from 26,500 to 35,000 tons. Clearly, therefore, the British Government's repeated attempts to restrict such vessels to 25,000 tons have definitely failed. Much as we may deprecate very large dimensions, it goes without saying that our new capital ships must be inferior to none in all the tactical qualities that count.

Great Britain's Oilfields and Hydrogenation.

Now that the regulations affecting the issue of licences for the prospecting and mining for petroleum in Great Britain have become effective, it is expected that numerous applications for such licences will be received. Broadly speaking, there are two kinds of licence issued—one for prospecting only, which covers a maximum period of five years, and one for mining, serviceable for a maximum of seventy-five years. Whatever may be the fortunes of the prospectors and mining companies who take up this sphere of activity, it is almost certain that the recently developed hydrogenation processes will play an important part in the treatment of any oil or oil-yielding material discovered. Unlike such countries as the United States and Russia, where oil is found almost as easily as water in Great Britain, it is most unlikely that oil-mining companies in this country could ever afford to operate on the same lines as in America, for example, where in the neighbourhood of the larger oil refineries one may see huge heaps of waste residue from the cracking stills. In America the incentive to apply hydrogenation methods to the

crude oil—and thereby to eliminate so much waste—is not so strong as in countries like Great Britain, in which the bulk of the motor fuel used has to be imported.

Briefly, hydrogenation serves to eliminate the bulk of the losses which occur in the cracking of crude petroleum through the formation of fixed gases and carbon by yielding a much higher proportion of low-boiling fractions from the crude oil, together with serviceable products, such as Diesel engine fuel, lubricants, &c., whilst the losses incurred are infinitesimal when compared with those of the cracking stills. In America the advantages of hydrogenating the crude petroleum and residues as an aid to the older distillation procedure in its entirety is being increasingly recognised; the Standard Oil Company of New Jersey, which has recently installed a large petroleum hydrogenating plant, being one of the pioneers in this direction. A feature of this plant is that the residues from the cracking stills may successfully be hydrogenated to produce up to 35 per cent. of petrol, the balance being a product requiring further distillation. From borings and tests made in various parts of Great Britain up to date, there is probably more likelihood of oil-bearing material being found in commercial quantities than of the discovery of extensive petroleum fields. It is well known that such oil-yielding materials exist in parts of Norfolk, in Dorset, and in North Wales. Some of this material is in the form of shales or torbanites, whilst some resembles the oily sands found in the regions of oilfields abroad. The shale oil industry of Scotland is, of course, an old-established one, about 1½ million tons of oil being produced there each year. In recent years, following upon the interest taken in the manufacture of home-produced motor fuel, the shale oil is subjected to improved processes to increase the proportion of oil suitable for the internal combustion engine. Hydrogenation is again playing an important part in this direction. Investigations on the oil-bearing material of Norfolk show it to have a relatively high sulphur content, nearly 7 per cent. By hydrogenating the crude oil obtained from the material, the yield of low-boiling fractions is increased from about 6 per cent. to about 22 per cent.; and simultaneously the detrimental sulphur content is appreciably reduced. Apparently, the fact that sulphur is combined in the crude oil offers no difficulties, providing that a suitable method of procedure is followed. The erstwhile handicap of hydrogenating such oils of high sulphur content has been largely overcome by the discovery of catalytic agents immune to sulphur, which had hitherto rapidly attacked, and so destroyed the life of, catalysts. The high moisture content of the oil-yielding material found in Great Britain is in no way disadvantageous to the hydrogenation process. During processing this water is first converted to steam, which is in turn decomposed, the hydrogen so liberated serving to hydrogenate the unsaturated hydrocarbons. In handling such materials as shales or oil earths, two distinct methods of procedure may be followed. The shales, &c., can first be treated in retorts for the recovery of the crude oils, and then afterwards hydrogenated to increase the proportion of low-boiling products. Or, the oily material may first be ground to a powder, then heated under pressure in the presence of hydrogen, when similar light hydrocarbons are produced. A process has also been recently evolved for the simultaneous cracking and hydrogenation of oils recovered from oily sands and earths, in which a mixture of steam and hydrocarbon vapours from the distillation of the oil is passed over the residue from the retorts, which residue is sufficiently high in carbon content to decompose the steam under heat treatment. This results in the cracking of the hydrocarbon vapours and the liberation of hydrogen, which, in turn, hydrogenates the unsaturated hydrocarbons present. In Germany a process is now in operation whereby peat and similar materials are hydrogenated under pressure with a mixture of carbon monoxide and water, the working temperature being sufficiently high to liberate the hydrogen from the water.

Modern hydrogenation processes have, accordingly, made available as raw material for the production of motor fuels and heavier oils vast quantities of carbonaceous substances which were before entirely without commercial interest. So that, although it is improbable that large areas in Great Britain will be turned into oil-mining districts as a result of the present activity in prospecting and boring, it is reasonable to assume that much oil-bearing material will be discovered which will be commercially workable through modern hydrogenation processes.

Literature.

Locomotives: Their Construction, Maintenance, and Operation, with Notes on Electric, Internal Combustion and Other Forms of Motive Power. By A. MORTON BELL, O.B.E., M.I. Mech. E., M.I. Loco. E. London: Virtue and Co., Ltd. 1935. Price 37s. 6d. Two volumes.

MR. MORTON BELL is to be thanked for adding to the scanty library of English locomotive books. For, strange as it may seem, the fatherland of the steam locomotive has produced very few good technical books about it. The most complete work in existence is Demoulin's "Traité Pratique," published as long ago as 1898 in four large volumes. After it comes Ahrons' "Development of British Locomotive Design" (1914), an admirable book in its way. With Pettigrew's "Manual," a year book or two, and a few volumes on specialised types of locomotives, the list is completed. Thus it will be seen that there was room and to spare for the kind of work which Mr. Bell has now attempted.

The arrangement adopted in Vol. I is the logical one of taking the separate and essential elements of locomotives in sequence, devoting to each a chapter—one on the Boiler, on Superheating, and Cylinders and Valves, on the Framing and Wheels, on Tenders, on Brakes, and so on. Each chapter is liberally illustrated with line drawings and here and there a few half-tones. The treatment is mainly descriptive, but enough general discussion is added to make the purpose of designs and invention clear to a reader unfamiliar with locomotives. Of criticism there appears to be very little, and the relative merits of different designs are not debated.

In Vol. II the operation of steam locomotives occupies the bulk of the space. Here we find chapters on Repairs, on Maintenance, on Combustion and Fuel, and Running Faults and Failures, and on Engineman, with an interesting chapter on Machine Shop Methods intercalated. The few remaining chapters deal with special types of locomotives, like the Garratt, the Kitson-Meyer, and the Löffler; with Internal Combustion and Electric Types; and finally, with representative types taken somewhat haphazard and not really representative, for no American, Canadian, German, or Indian engines appear. It would, we suggest, have been better to devote the space available, not many pages, only to the latest British examples.

As we have said, we welcome the volumes as an addition to a scanty library, but useful as the book is, it leaves room for a much larger and much more complete work. We fear, however, that there is little chance of that work ever being undertaken unless one or more of the institutions will meet the expenses. Mr. Bell's book, which is obviously intended for amateurs of the locomotive as much as for locomotive men, will probably meet with a remunerative sale, but such a work, as we have in mind, for the reputation of an industry of which this country is the father, would be too costly in present circumstances for any save deep pockets. We have always felt that such a great work should be written, and we live in the constant hope that some enthusiastic individual, if not some corporate body, will find the wherewithal—several thousands of pounds perhaps—to have it done.

The Principles of Motor Fuel Preparation and Application. Vol. II. By ALFRED W. NASH, M.Sc., M.I. Mech. E., F.C.S., F. Inst. Fuel, and DONALD A. HOWES, B.Sc., Ph.D., A.M.I.P.T. London: Chapman and Hall, Ltd. 1935. Price 30s.

THE first volume of the "Principles of Motor Fuel Preparation and Application" appeared several months ago, and it has already become a recognised text-book amongst petroleum technologists. The second volume, which now appears, gives another 500 pages of concise information, and the entire book undoubtedly deals far more adequately with the subject than anything which has previously been written.

The first volume was occupied primarily with a description of the methods employed for the production of petroleum motor fuels, products manufactured by the hydrogenation of mineral oils and coals, and with the production of alcohols and synthetic fuels. The second volume deals with the properties of the products, and the methods employed for testing and evaluating them.

In the analytical section the test methods are very briefly described. It has to be taken in conjunction with the official books describing standard methods issued by the American Society for Testing Materials and the Institution of Petroleum Technologists. There has been no attempt to re-copy the detailed descriptions given in these two volumes.

Apart from the standard methods used internationally many other analytical methods and instruments are described, such as the Podbielniak high-temperature fractional distillation apparatus, and chemical tests such as those of disulphides, sulphides, and thiophene. The chemical methods used for the determination of the basic types of hydrocarbons are reviewed in considerable detail, and more thoroughly than in any work on this subject.

Later chapters deal with the significance of analytical results, such as the effect of sulphur in the fuel on engine performance, and the formation and significance of gum in motor fuels; the use of gum inhibitors is also reviewed.

The latter half of the book deals more particularly with the engineering side of the subject, beginning with a review of the thermo-dynamics, carburation, and the performance of different types of engines. The significance of volatility is the subject of a special and somewhat lengthy chapter, as is, also, the subject of knock rating. Specifications for motor fuels are given in this section, and the change in quality of spirit over the last few years is studied. That is a subject of particular interest, as the improvements, both in octane numbers and in volatility of American and British grades of petrol are, to some extent, an indication of future tendencies. Specifications of fuels utilised in different countries are given, and the last portion of the book deals with the design and performance of high-speed C.I. engines, with particular reference to the process of combustion and the influence of spontaneous ignition temperature on performance.

There is no doubt that Professor Nash and Dr. Howes are to be congratulated on having given us an exceedingly fine work, which is likely to remain for several years the standard book on this subject.

SHORT NOTICES.

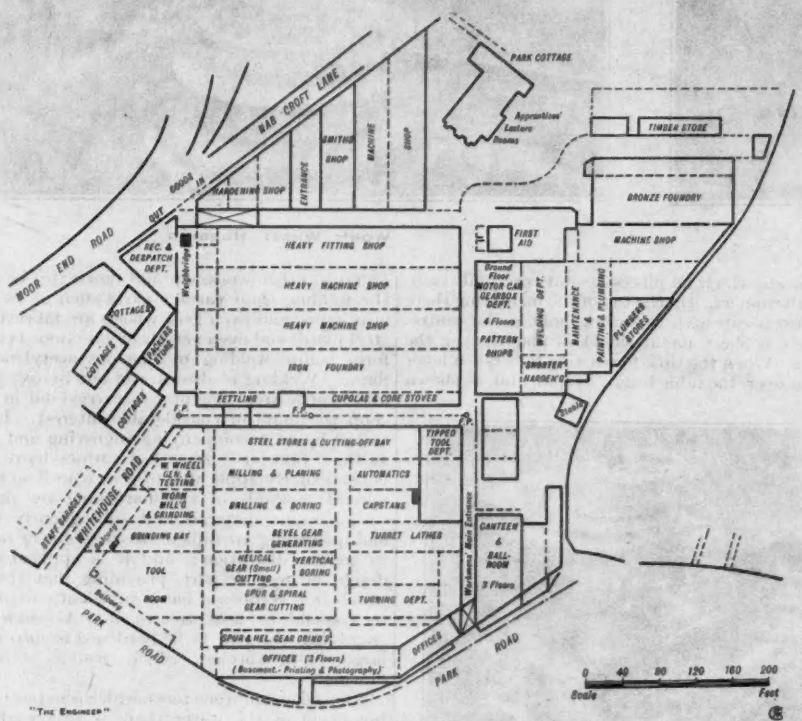
Electric Water Heating. By D. J. Bolton, Philip C. Honey, and N. S. Richardson. London: Chapman and Hall, Ltd. Price 7s. 6d.—Written with special reference to the domestic storage heater and divided roughly into three parts, dealing respectively with the apparatus, the installation, and the supply, this book should prove useful to all who desire to familiarise themselves with the problems that arise in connection with the electrical heating of water in the home. Supply engineers who are anxious to develop a water heating load are given the benefit of the experience of Mr. Honey, who, for twelve years, was on the staff of the Croydon electricity undertaking, while contractors should derive assistance from the contributions to the volume by Mr. Richardson, who has been responsible for many domestic water heating installations. Mr. Bolton has made a special study of the economics of electricity supply and domestic utilisation, and the book, therefore, has the merit of having been prepared by authors in a position to deal with the subject from different angles. Attention is paid to the construction of water-heaters, and to their operation and lay-out. A chapter dealing with the chief types on non-electric hot-water systems is followed by one on their adaptation to electric working. Other chapters deal with electricity consumption, supply aspects, loads, tariffs, and costs, restricted service schemes, and apparatus sales and service. As far as we know, there is no other book devoted entirely to electric water heating, and the authors therefore appear to have rendered useful service in writing this volume.

The Measurement of Inductance, Capacitance, and Frequency. By A. Campbell and E. C. Childs. London: Macmillan and Co., Ltd. Price 30s.—Students and engineers seeking information on the measurement of inductance, capacitance, and frequency will find in this volume a vast amount of material. The early part is based on articles written by one of the authors for Glazebrook's "Dictionary of Physics." Much new matter has, however, been added, including some on A.C. potentiometers and the measurement of frequency. In nearly all cases the problems discussed relate to A.C. circuits. To provide a firm foundation for these discussions, the authors begin with the more fundamental definitions and introduce the nomenclature and symbols used as systematically as possible throughout the book. The mathematical treatment is nearly all of the most elementary nature, and unlikely to present difficulties to those who take an interest in electrical measurements. Composed of over 470 pages, exclusive of the index, and containing 453 illustrations, the volume covers a wide field and should appeal to many engaged in practical electrical work, in addition to students and teachers of electrical engineering. The authors regret that it has not been practicable to bring the book out in simplified spelling, for, in their opinion, the conventional spelling is an inadequate representation of our English language.

Photo-electric and Selenium Cells. By T. J. Fielding. London: Chapman and Hall, Ltd. Price 6s.—Although it cannot be said that electrical writers have failed to give photo-electric and selenium cells the attention they deserve, this book appears to meet the needs of those seeking information in concise form relating to their operation, construction, and uses. Amateur experimenters interested in the practical application of these cells will find the book useful. All the experiments described are of an elementary nature, and serve to familiarise the reader with the many uses to which the cells can be put. The application of the cells to television, talking pictures, and general industry is described, with the help of diagrams and pictures. The use of the cells in advertising is also discussed. The two final chapters are devoted to exceptionally ingenious applications and potential applications. Extensive as the use of light sensitive cells is, the author believes that the field of application will continue to widen.

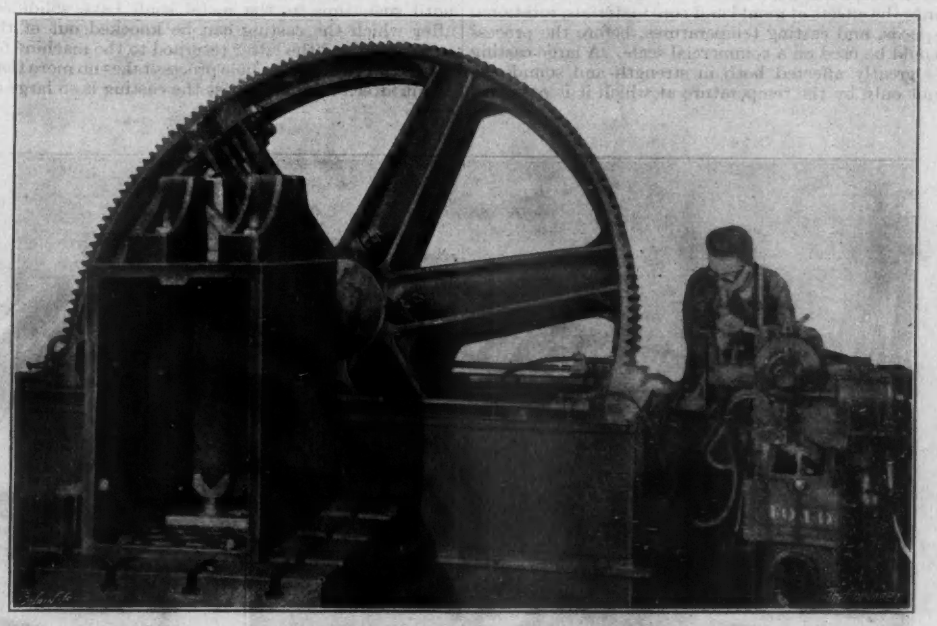
Gear Works of David Brown's, Huddersfield.

WHOEVER sets out to manufacture gears needs not only a considerable knowledge of mathematics, but also some facility in dealing with geometrical problems. That fact was very forcibly impressed upon us during a recent visit to the Park Works of David Brown and Sons (Huddersfield), Ltd. Anyone who has seen a Maag gear grinder at work and seen how it makes use of a ribbon unwinding from a roller to generate the involute form will have realised the importance of geometry in the making of spur and helical gears. But, if the necessary knowledge of the geometry of spiral bevels is absent, the queer motions of a Gleason bevel-cutting machine are unexplainable, while, though its presence is not obvious in the machining operations of worms and wheels, any attempt to work out the theory of the action of this class of gearing at once involves the student in problems of solid geometry.



LAY-OUT OF PARK WORKS

The use of gears for high powers and high speeds is quite a modern development, but gears are, of course, very much older than their modern applications. The firm of David Brown and Sons, which has always been concerned with gears, is more than seventy years old, and there are those still living who can remember the time when it manufactured patterns for gear wheels with cast and morticed teeth. It was founded by the late Mr. David Brown, father of the present chairman, who set up a business as a pattern-maker in Huddersfield in 1860. His speciality was the making of gear wheel patterns, and with the coming into the business of his sons, more and more attention was concentrated on the requirements of gearing. Soon machinery was installed for the accurate spacing of gear teeth, and the gears themselves began to be manufactured and not only the patterns. Studies were made both theoretically and practically, with the object not only of discovering efficient tooth forms, but also those which could most easily be manufactured. By 1890 it was becoming clear that the cast gear could be much improved upon by machining the teeth, and in that year the first machine for the cutting of gears was installed. From that year onwards the gear shop became of ever-increasing importance, so that it completely outgrew the patternshop. Meanwhile, the business of the firm was extending in consonance with a rising reputation. By 1902 the space available was found inadequate for the work in hand, and it became necessary to acquire a larger site in which room would be available for the development the directors could now foresee, and the present Park Works was set up. With the opening of the present century, the motor car and lorry began to assume importance, and from the fact that beginning about 1906 great attention was paid to worm gearing, it may be assumed that it was the demands of the road transport industry that gave the necessary incentive. The worm gear had been manufactured at a much earlier date, for even in 1903 standardised worm reducers were being made at Park Works, but, in distinction to its present reputation as a highly efficient means for the transmission of power for industrial or traction drives, it was at first regarded only as a form of gearing to be avoided if any other type was suitable. Later, the development of the spiral bevel began. Naturally, the coming of the geared turbine had repercussions on the firm, but it had long been paying attention to the design and manufacture of helical gearing which now forms a considerable part of its activities. Shortly before the war, the Timken-David Brown Company—now absorbed in the Timken Detroit Axle Company—was formed to manufacture the "D.B.S." patent worm drive in U.S.A. The war caused considerable extensions to be made, so that a high rate of production could be achieved. Soon after the conclusion of hostilities, and with the object of still further increasing the productive capacity, the firm acquired the business of the Keighley Gear Company (as successors to "Sam Sunderland"), which now produces small and medium-sized gears for industrial purposes. The works of this company were transferred to a new and larger site close by that of the parent company's works. Again, in 1930, and with the same object, the company embraced the old-established firm of P. R. Jackson and Co., Ltd., of Manchester, for the manufacture of heavy gearing, rolling mill plant, and steel castings. But despite these activities, the amount of orders coming to the works of the parent company has constantly increased, necessitating further expansion, and recently a 29-acre site and extensive buildings at Penistone have been acquired, and are, we understand, to be especially devoted to the manufacture of castings and heavy gears.



THE "SHORTER" HARDENING PROCESS

THE SHOPS.

One of the first impressions we gained on entering the light and medium machine shop, which lies immediately behind the offices, was one of orderly tidiness, despite the obvious fact that the plant was working up to its full capacity. Gangways, delineated by the white painted lines which so many firms are now adopting, lie between the rows of machines, and the various work pieces were all tidily arranged behind these lines clear of the gangways. This large shop contains machine tools for the manufacture of all the types of gears made by the firm. It is divided into three main parts. To the left in a triangular-shaped portion of the building there is situated the tool-room, and close around it there are arranged machines for the various finishing processes. The central division is concerned principally with the cutting of gears and worms before hardening, while in the last division—that on the right—there are arranged such tools as capstan and turret lathes, which prepare the blanks for the later processes. Beyond the light machine shop, and separated from it by "Foundry" road, there is another large shop with four bays. One bay, that nearest to the road, is utilised as the ironfoundry, while the remaining three constitute the heavy machine and fitting shops. The ground rises from the left-hand end of this shop towards the right, and an interesting use has been made of this peculiarity by running a road beneath the left-hand end of the shop to connect with "Foundry" road. Heavy parts can therefore be lowered directly by the machine shop cranes into lorries standing on the road. The hardening shops and forge are arranged in another building beyond the heavy machine shop. On the right another road—"Pattern Shop" road—separates the heavy machine shop from a five-storey building housing the pattern shop and stores. Behind this building there is the welding department, and a shop devoted to the repair and maintenance of plant. Further away still and on rising ground there is situated the bronze foundry, and at the head of "Pattern Shop" road there still exists a cottage which was built long before the firm erected its works. This cottage is used in part as an apprentices lecture-room and for similar purposes. In every part of the works there are machines or operations of great interest to witness. Space, however, forbids us to enter deeply into all that each visitor may see. Necessarily we must confine our descriptions to those parts of the works or those machining operations which are most striking or least well-known to engineers in general.

THE BRONZE FOUNDRY.

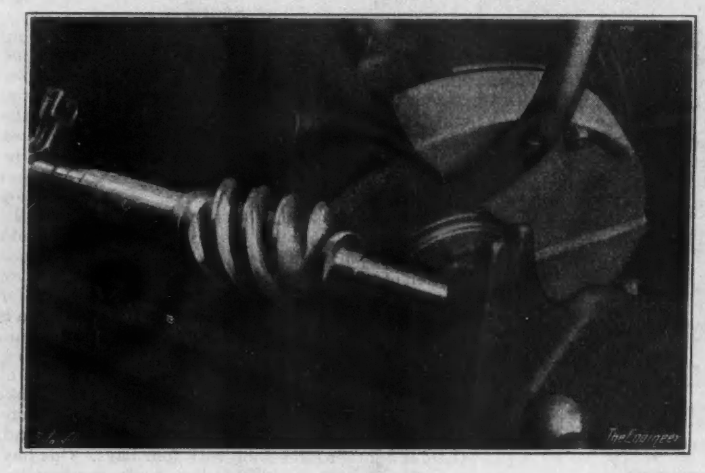
Worm gearing, as everyone knows, is designed both from the point of view of strength and that of wear, and in this connection the material used for the wheel becomes of primary importance. Since in the operation of the gears, relative sliding takes place between the teeth in contact, it is necessary that the metal of which the wheel is composed shall have some of the properties of a bearing alloy, and in general, bronzes are used. Messrs. David Brown and Sons make all their own phosphor bronze castings, and as a result of much research the firm has developed a series of bronzes known by the trade name of "Taurus," which have properties especially suitable

for a variety of other purposes besides that of forming worm wheels. For the latter purpose, with which we are more particularly concerned, an alloy with the approximate composition copper 87·7 per cent., tin 12 per cent., phosphorus 0·3 per cent. is used, and centrifugally cast yields the following physical properties:—

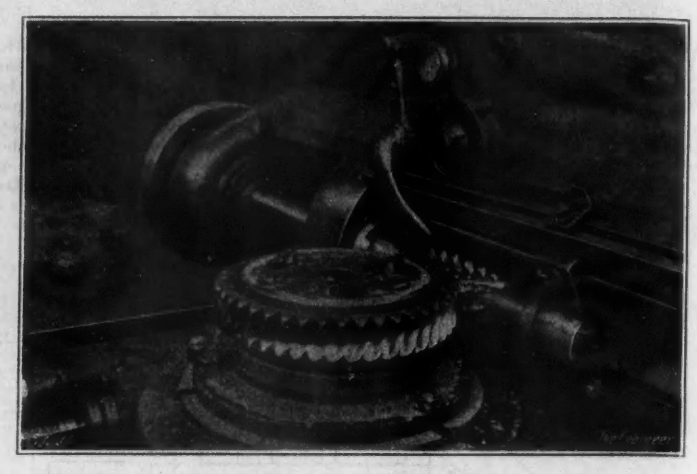
Yield point	13–16 tons per sq. inch
Maximum stress	17–21 tons per sq. inch
Elongation	2–7 per cent.
Brinell test (1000 kilos. with 10 mm. ball)	90–110
Izod (20 mm. by 20 mm. notched)	19–25 foot-pounds
Weight per cubic inch	0·312–0·319 lb.

The centrifugal process of casting was originally developed by the firm especially to improve the quality of worm wheel blanks for automobile work, but its scope has since been extended to industrial gears up to 6ft. diameter. The superiority of centrifugally-cast bronze over sand-cast bronze of identical analysis, and over chill and die castings, particularly in regard to resistance to abrasion and compressive stresses, arises from the effect on the microstructure of the combination of rapid cooling, the high fluid pressure consequent upon the rotation of the mould, and the constant agitation during the whole period of solidification. While we were examining the very interesting laboratory of the firm we were privileged to see on the screen of the micro-camera projections of the structure of centrifugally and sand-cast bronzes in which the great difference of structure was made most impressively visible. There is not only a greater density, but a finer distribution of the hard particles of the copper-tin eutectoid on which the resistance of the material to wear and surface pressure depends. It might be thought, especially after observing the simplicity with which it is carried out in practice, that there is no difficulty to be overcome in centrifugal casting of bronze. In actual fact, however, we were informed by the firm that many years of development were necessary, together with research into the effects of mould and core materials, rotational speeds, and casting temperatures, before the process could be used on a commercial scale. A large casting is greatly affected both in strength and soundness, not only by the temperature at which it is cast, but also on the rate at which it solidifies and cools. In determining this casting temperature, therefore, the size and disposition of the runners and the size, shape, and section of the casting must be taken into account; it cannot be fixed at any one point for all moulds.

None of these matters is immediately obvious when the bronze foundry is first visited. Twenty-six centrifugal casting machines, suitable for castings up to 2000 lb. in weight, are arranged on a clean cast iron floor, as shown in one of the engravings in a Supplement to this issue. On the rotating plate of each machine there is laid by the moulder a ring of metal, inside which he places a sand core built complete with runners. On the top of the metal ring there is clamped a cap with a pouring hole in the centre. Thereafter a sheet metal shield is placed over the machine. When the time for casting falls due a lever is thrown over, the table begins to spin, and, as shown in the engraving, the metal is poured in from the ladle. It only remains to keep the machine running until such time as the metal shall have solidified, after which the casting can be knocked out of the ring mould and the latter returned to the machine for further service. The whole process takes no more than about fifteen minutes unless the casting is so large as to require a long period to cool. As may be inferred from the engraving, the centrifugal department is only one section of a bronze foundry equipped also for sand, chill and die casting.

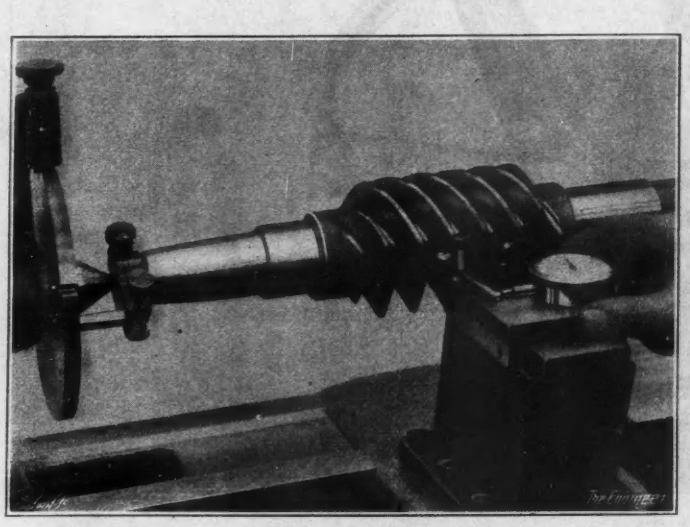


WORM GRINDING

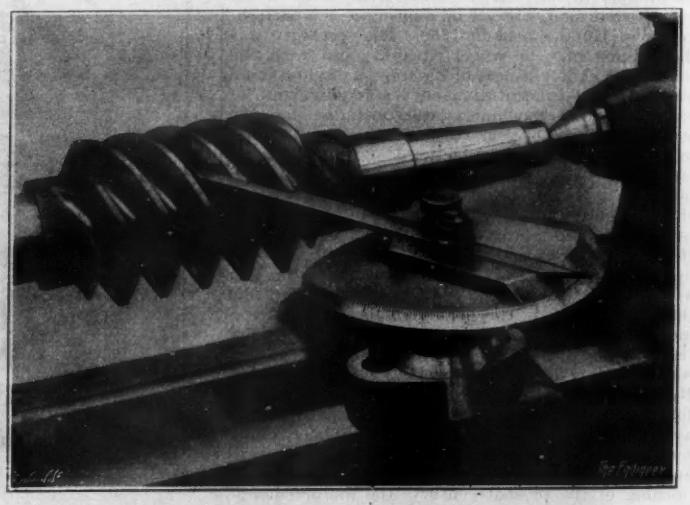


WORM WHEEL HOBBING

LAPPING A WORM



TESTING A WORM FOR PITCH



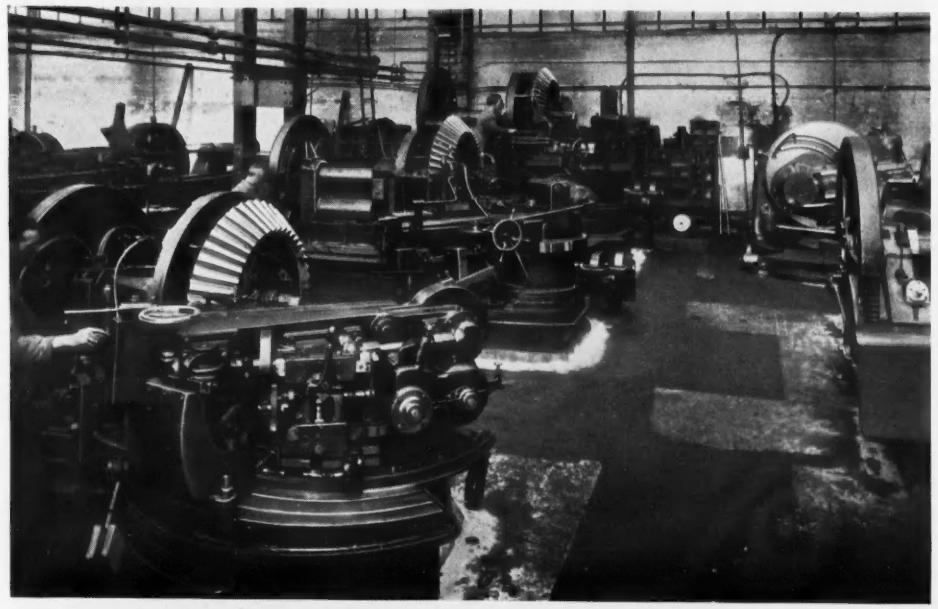
PROFILE TESTING OF A WORM

The Welding Department.

Little reference need be made to either the iron-foundry, the pattern shop, or that portion of the light and medium machine shop, which is devoted to the preparation of material for subsequent and more interesting processes. In nearly every respect those sections of the works are similar to those to be found in other works up and down this country. In the welding shop various parts such as base-plates, gear cases, and even gear wheels are fabricated, mild steel plates and even very heavy sections being cut to form before welding by the oxy-acetylene cutting flame. Welding is also carried out by oxy-acetylene and electric arc. One process carried out in the same shop we found of considerable interest. It is illustrated by an accompanying engraving and is known as the "Shorter" process of surface hardening. It is particularly applicable to gear wheels so large that normal methods of case-hardening by packing in carbonaceous material and subsequently reheating and quenching are difficult to carry out or might lead to serious distortion; and it is applicable to any design of gear or part, providing that the steel of which it is composed has a sufficient carbon content to respond to heat treatment. As shown in the engraving, the gear to be hardened is suspended in a large bath, through which water is constantly flowing.

Along one side of one tooth which is in position partly immersed in the water there is traversed an oxy-acetylene flame which raises the temperature locally to the desired degree. This flame is mechanically traversed along the tooth at a rate which will realise the desired temperature. Carried by the nozzle an inch or so behind the flame there are a number of jets, dependent on the width of the tooth, gently spouting water on to the heated surface and so providing the required quench. After each tooth is dealt with the gear is turned one tooth so that the one just hardened is submerged in the bath completely. It will be seen that the process involves very slight risk of distortion of the part hardened, and experience has shown that the hardened portion persists in only slightly diminishing degree well down into the material. Moreover, the process has the additional advantage that the root of the tooth remains unaffected so that at this important point the full toughness of the original material is retained. For plain carbon steels to be "Shorter" hardened the most suitable range of carbon content is from 0·40 per cent. to 0·70 per cent. for forgings, and from 0·48 per cent. to 0·55 per cent. for castings. The manganese content in both cases should be 0·40 per cent. to 0·80 per cent. Many of the alloy steels are also used

THE PARK WORKS OF DAVID BROWN AND SONS (HUDDERSFIELD) LTD.



ABOVE:—GLEASON BEVEL GEAR GENERATORS
BELOW:—THE HEAVY MACHINE SHOP

ABOVE:—THE CRANE SHOP IN 1917
BELOW:—THE HEAVY FITTING SHOP

BELOW:—THE HEAVY MACHINE SHOP

BELOW:—THE HEAVY FITTING SHOP

THE PARK WORKS OF DAVID BROWN AND SONS (HUDDERSFIELD) LTD.

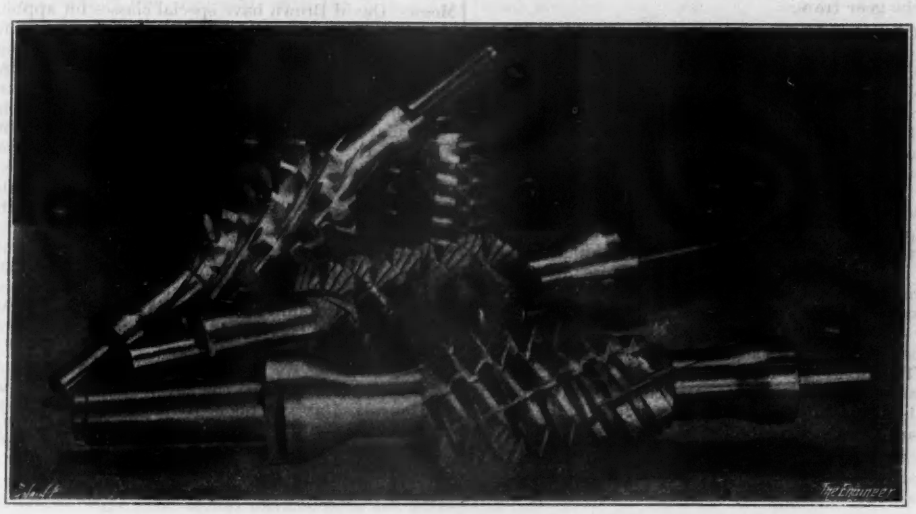
ABOVE:—CENTRIFUGAL CASTING IN THE BRONZE FOUNDRY
BELOW:—WORM WHEEL HOBBING MACHINES

ABOVE:—WORM GRINDING MACHINES
BELOW:—WORM AND WORM WHEEL TESTING MACHINES

with good results and the process is also used for cast iron gears and other parts.

THE LIGHT AND MEDIUM MACHINE SHOPS.

It is with some trepidation that we enter upon a description of the machine shops, because the production of gears of all kinds involves a number of more or less specialised processes for the full understanding of which considerable experience is necessary. As we have already mentioned, a part of these shops is devoted to capstan and turret lathes, automatics, milling and planing, and drilling and boring machines. Although several of these machines are of the finest and most modern design, considerations of space forbid us attempting any description of them in view of the fact that in the remainder of the shops there are other more specialised tools demanding notice.

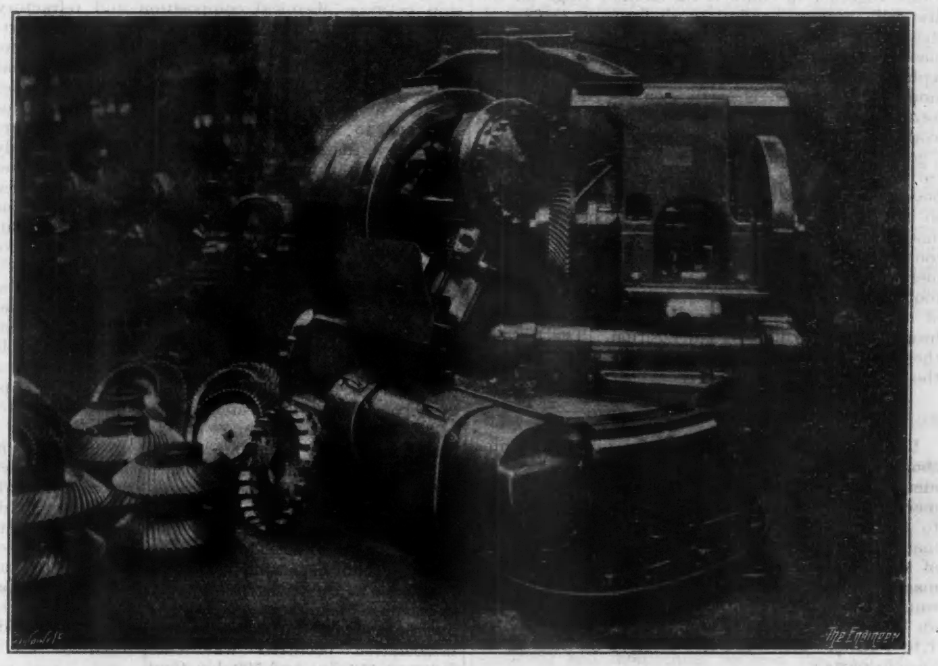


WORM WHEEL HOBS

Reference may first be made to the production of worms and wheels. All worms are forged in order to secure the best mechanical properties in the steel and in order to simplify construction the worm, whenever possible, is formed integrally with the shaft. After cutting to length and rough machining the worm shaft ends undergo a preliminary grinding operation to facilitate accurate location of the blank during cutting of the threads. This latter operation is performed in a worm milling machine. The worm shaft is securely held in a horizontal position by a powerful collet chuck at one end, while its other end rides in a roller steady. The horizontal work table carrying the chuck and steady is supported on a long vee slide and the face is inclined at the best angle for withstanding the cutting stresses. The cutter, which is profile ground to the required form, is rotated in a head which can be tilted into the position necessary for cutting a worm with any specified lead. In operation the work table traverses slowly past the cutter head while the work is at the same time rotated. In all but the largest sizes each worm thread can be cut to the full depth at one traverse: On completion of the horizontal motion of the table the cutter head is withdrawn and the table returns to its first position. If the worm has more than one lead, indexing is now carried out and the table retraverses on another cutting stroke. The relative horizontal motions of the table and rotary motion of the blank are controlled by change wheels. At the conclusion of this operation the worm is rough ground before hardening, as it has been found that by this means a more accurate surface can be obtained, while the depth of case is more uniform and the amount of material to be removed in the final grinding is reduced. Final grinding is carried out on a machine very similar to that for milling. The principle is one of generation from a flat-sided wheel which is trued periodically and always before the final cut by an accurately guided diamond. Only one side of the wheel is ground at a time, the worm traversing and rotating past the wheel repeatedly. At the end of each stroke the worm is withdrawn from the wheel and returned to its starting point, indexing taking place before the next stroke is begun. When one side is finished the operator removes the worm from the machine and reinserts it the other way round, and the operation of grinding is repeated on the opposite flank of the worm thread. An accompanying engraving shows a twin start worm being ground, while illustrations in the Supplement show groups of worm-milling and worm-grinding machines.

Before the final lapping operation, to be described later, is performed, the worms are tested and inspected for concentricity, thickness of thread, pressure angle, pitch and indexing. Most of the methods used for measuring these qualities have been described at one time or another in THE ENGINEER, and we do not intend to enter deeply into the subject. In testing for thread thickness a steel ball of suitable diameter is inserted in the space between two adjacent threads of a master worm and the spring plunger of an indicator, and the pointer of the indicator is set to zero. The master worm is then replaced by the worm, of which the accuracy is to be checked, and the same process carried out, but without readjusting the indicator. The readings on the dial will then show any variation in comparison with the master worm. It deserves notice that by reason of the inclination of the sides of the thread, any variation of thickness will be multiplied on the vertical scale, and minute errors can thus be detected. In profile testing, the subject of an illustration, a straight edge is clamped in a groove in the rotating part of a protractor and swivelled so that its edge lies along the fundamental straight line of the worm thread. In passing, it may be noted that it is upon this line that the flat edge of the grinding wheel which finished the worm operated. The inclination of the line is shown on the protractor scale. A special measuring apparatus (not shown) enables the inclination to be measured for accuracy to within half a minute of angle. Another engraving shows the method of testing for pitch. Essentially, the instrument consists of a slide on which there is mounted an indicator and fixture carrying a ball. Also carried on the slide rotatably there is a stylus carrying a ball at one end and bearing against the rod of the indicator at the other. By pushing the slide inwards so that the two balls enter adjacent thread spaces any variation of pitch will become immediately measurable on the clock of the indicator.

The final lapping operation which all worms undergo does not remove any appreciable amount of material, but takes out all grinding marks and is found to give a greater length of life to the wheel with which the worm meshes. Lapping machines of the type now used by the firm have only recently been produced, and, like other gear-making machinery, have been put on the market. A near view of a machine is reproduced in an accompanying engraving. The worm to be lapped is mounted on the spindle of the machine, which is driven by a direct-coupled electric motor. The lap itself, which is made of special composition, is driven by the worm. Lapping compound is distributed over the work by adjustable nozzles. In operation the work table reciprocates back and forth, so that the whole length of the worm is lapped. By means of a neat mechanism in a timing box on top of the work headstock, the rotation of the work spindle is reversed after a predetermined number of strokes, and, after the completion of an equal number of strokes with reversed rotation, the machine stops automatically. A suitable range of speeds and mechanisms for setting the correct centre distance, &c., are, of course, provided, and there is a cover which may be raised when the machine is operating so that lapping compound is not splashed around. Coming from the lapping machine the worm is complete.



25IN. GLEASON CURVED-TOOTH BEVEL CUTTING MACHINE

WORM WHEELS.

Worm wheels, as has already been mentioned, are made from "Taurus" bronze, cast, except for the exceptionally large sizes, centrifugally. After dressing and cleaning, the cast blanks are finish turned, drilled and slotted, according to the particular design concerned. The turning operation is carried out for the smaller sizes on special-purpose lathes. The teeth themselves are cut by hobs as shown in an engraving. Several different forms of hob are employed, and a number of types are illustrated in another engraving. Two alternative modes of procedure are available. The worm wheel blank may either be roughed out by one hob and finished by a second hob, or, alternatively, a combination hob can be used. All hobs may be regarded as worms, gashed across the threads, and combination hobs are also tapered in much the same manner as a tap. Machines for using combination hobs have both radial and tangential feeds, which can be used independently or together at will, so that for the roughing operation at the small end of the hob the work is fed radially into the hob until, when the correct centre distance has been obtained, the tangential feed operates to traverse the work along the hob towards the large finishing end. When this latter feed is in operation, the rate of rotation of the hob relative to that of the work table has to be modified in accordance with the rate of tangential feed, and means for making this correction automatically are incorporated in the machine. Special testing machines working in conjunction with a master worm are used for testing the accuracy of the finished worm wheels.

THE HARDENING SHOP.

The firm has one of the largest and best-equipped hardening shops in this country. The total connected load of the various electric furnaces amounts to more than 1000 kW. From an illustration on page 66 the neat appearance and lay-out of the shop will be appreciated. The major part of the carburising work is looked after by four 105 kW furnaces, with mechanical loading and unloading machines. These furnaces are equipped with automatic temperature control devices, while continuous recorders demonstrate that every part undergoing hardening has received the correct treatment. Electrically operated time switches for each furnace, moreover, ensure the maintenance of predetermined time-temperature conditions. Besides these large furnaces, there are a number of others similarly equipped with controllers and ranging from 12 kW to 200 kW rating, in which subsequent refining and

general heat treatment can be carried out. Oil, water, and lime-quenching systems are employed, and refrigeration apparatus ensures that an adequate flow of temperature-controlled fluid shall pass through each system. Many of the parts manufactured, such, for instance, as bevel gears, are liable to serious distortion in the hardening process, and to prevent its occurrence quenching is carried out under hydraulic pressure on machines especially designed for this purpose. For the avoidance of carburising surfaces unnecessarily, extensive use is made of copper plating. The firm has developed specially to meet the requirements of gear case-hardening a carburising compound of its own.

The Production of Helical Gears.

As the making of helical and spur gears is a process carried out in many works, we do not propose to say very much about this activity at David Brown's. Almost every known method has been and is still used by the firm. For the making of triple helicals, for instance, which are still used for mine-hoisting gear and in similar applications, an end-mill cutter forms the teeth, since no other machining method is possible. But for single and double helicals either shaping or plano-"generating" methods are preferred. Most of the smaller gears, both single helical and spur, are ground on Maag gear grinders. As will be seen from photographs taken at the time of our visit and reproduced in the Supplement, some very heavy gears were going through the shops. As a contrast to such wheels our guide produced from his waistcoat pocket a little wheel less than ½in. diameter, also made by the firm with correctly formed involute teeth. The large gears were by no means the largest ever made by the firm, nor was the "baby" the smallest.

Spiral Bevels.

Spiral bevel gears are assuming an increasing importance in industry since they have the same kind of superiority over the straight-tooth bevel as the helical gear has over the spur gear. At the works of David Brown there is a large "battery" of "Gleason" cutting machines for making them. The principle on which a "Gleason" machine works is more easily demonstrated by the use of a cardboard disc and two conical tea-cups than it can be described. Two spiral bevels that would mesh together would also mesh with a disc on which suitable teeth had been cut, always providing that the centre of rotation of the disc lay on the axes of the bevels. For the sake of description, imagine a disc to be made of hard steel and that a circle, with its centre between the edge and the axis, is described upon it and formed as a circular ridge. Let the disc drive a bevel blank made of some plastic material. Then, as the two rotate together in contact, the circular ridge on the disc will impress a spiral tooth form on the bevel. Referring now to the engraving of a 25in. "Gleason" machine, it will be seen that the "raised" circle is replaced by a rotary cutter which, instead of being mounted on a disc, is carried on a cylindrical and rotatable head. The bevel blank is carried by a work head at an angular setting such that it would "gear" with an imaginary disc passing through the cutters. In action, the work head cylinder and the bevel blank rotate as though gearing together so that the cutter forms a single tooth. After a motion sufficiently great for the whole length of the tooth to be cut, the bevel is swung out of "engagement" by the work head, and indexing for the next tooth takes place. At the same time, the motion of the cutter head is reversed so that the cutter is brought back to its original position. The bevel is then swung in again and the cycle repeats itself until the work is complete.

The Heavy Machine Shop.

Little need be said about the heavy machine shop, for the work carried out in it is in most respects identical, except for scale, with that done in the light machine shop. Reference, however, may be made to the large 60in. "Gleason" spiral bevel cutting machine illustrated on page 66, because its method of operation is rather different to that of those machines described in the last paragraph. It is suitable for cutting gears up to 5ft. in diameter with an 8 to 1 ratio, and up to 3ft. 6in. diameter with a 1 to 1 ratio. There are five relative motions of the various parts:

(1) The blank rotates continuously at a constant speed. This motion is one of the factors producing the spiral form of tooth and also brings about a continuous indexing action, which is a departure from the intermittent indexing of most bevel gear cutting machines in commercial use.

(2) The tool is reciprocated by a crank and connecting-rod. During one revolution of the blank the tool makes as many strokes as the number of teeth being cut, *i.e.*, the tool enters a new tooth space at each successive forward stroke, and has to be withdrawn from the cut to clear the face of the gear during the return stroke.

(3) The cradle which carries the tool slide is oscillated slightly by means of a continuously rotated excentric which makes two revolutions while the crank makes one. This motion of the cradle compensates for the slowing up of the tool towards the end of the cut, and is an important factor producing the desired shape of tooth spiral. The connection between the cradle and the excentric is made by means of the cradle worm, which is reciprocated in the direction of its axis.

(4) The cradle is given a very slow rotation continuously in one direction to swing the tool either upward or downward about the machine centre for the purpose of generating the tooth profile. The rotation of the cradle is effected by rotating the cradle worm.

(5) A component rotation of the blank for profile generation corresponding to (4) is added to the indexing rotation (1) by differential mechanism in the gear train.

Of these five motions the first three determine the shape of the tooth spiral curve, and the last two constitute the relative rolling motion used in all bevel gear generating machines to produce the profile curve.

Theoretically, the spiral tooth curves in gear and pinion are supposed to be identical, which would result in contact throughout the length of teeth. In practice, however, it is very desirable to have a somewhat shorter length of tooth bearing, and this requires a slight difference in the radii of curvature of the tooth spiral. In addition to making it possible to cut a spiral tooth with a curvature in only one direction in a continuously rotated gear blank, with a crank-driven tool, the oscillating motion induced by the excentric also provides the most convenient means for slightly changing the radius of curvature.

The kind of localised "tooth bearing" thus obtained is found to be of as much practical advantage in large bevel gears as it has proved to be in the smaller gears used in automobile rear axle drives.

Conclusion.

We are well aware that in preparing this article there is very much which we saw on our visit to the works which we have not described. In place of description the many photographs reproduced in a Supplement, on page 66, and herewith, must suffice. Volumes have been written and still remain to be written about the production of gears, and in an article such as this we can but hope to have given some idea of the scope of the work carried out by Messrs. David Brown, and the methods of production that the firm employs. Before closing this account some reference should be made to the "human" side of the undertaking. Like many other firms, Messrs. David Brown have special classes for apprentices and a special department concerned with looking after their welfare. But the matter goes further. As far as that is possible in a concern employing 2000 men, the individual circumstances and character of each employee are studied. If, for instance, one particular man is constantly suffering small accidents in his work an attempt is made either to find some means of preventing their occurrence or alternatively of discovering some other occupation for which the man is more suited. Moreover, and especially in the case of apprentices and the younger men, so-called psychological tests are applied to discover manual dexterity, quickness of thought, &c., so that the probable occupation for which the employee is best fitted may be found without delay and disappointment. The firm has found these tests of considerable value.

In conclusion, we should like to take this opportunity of acknowledging the courtesy with which we were received at and taken round the works by the representatives of the firm.

The Institute of British Foundrymen.

No. II.

(*Concluded from page 35, July 12th.*)

Refractories for Foundry Use.

A PAPER was presented to the conference by Mr. W. J. Rees, M.Sc. (Head of the Refractories Department of the University of Sheffield). In it he dwelt upon various aspects of the refractories problem, including glaze and abrasion resistances, the occurrence of black cores in bricks, corrosion resistance, the importance of close jointing, rammed linings, patching materials, &c. In a reference to the relationship between chemical composition and refractory value, he suggested that sometimes too much importance was attached to refractoriness as such; there were occasions on which a product of somewhat lower refractory value might give greater service because of its tendency to become glazed and thus resistant to abrasion more rapidly than a more refractory material. Some of the comparatively lower grades of fire-brick would actually give better service in some types of cupola practice than even the higher grades of fire-brick, because they became hard and tough more quickly when in service. But in the modern cupola the very highest qualities of fire-brick were essential.

Another point emphasised was the importance of mechanical strength of refractory materials at high temperatures. It was not always realised that a fire-brick having a cold crushing strength of 7000 lb. or 8000 lb. per square inch might crush, when at a temperature of 1500 deg., at a load of perhaps 20 lb. per square inch, and in the cupola, pressures of 20 lb. or 30 lb. per square inch were attained.

Another factor mentioned was the disintegration of bricks by the internal deposition of carbon when the bricks came into contact with carbon monoxide at not very high temperatures, owing to iron oxide acting as a catalyst. That had happened quite frequently in the blast-furnace, but not so much since reaction had been understood and could be side-tracked. In the cooler parts of the cupola there was occasional disintegration from that cause. The optimum temperature at which carbon monoxide dissociation occurred was comparatively low—between 450 deg. and 500 deg. Cent.

In rammed linings and patching, the ratio of silica to alumina was often of very great importance. It was desirable to keep clear of the eutetic round about 90 per cent. of silica, because that was the region of lowest melting point. It should be either from 1 to 3 per cent. higher or 10 or 12 per cent. lower.

Mr. Rees paid a tribute to the manufacturers of ganister in the Sheffield area for the immense amount of work they were carrying out, and said there remained a good deal of matter for investigation in the future, not only by the maker and user of refractory materials, but also by the designer and user of the cupola.

Sand Problems in a Brass Foundry.

Mr. F. Howitt presented a fairly detailed paper on sand problems in a brass foundry. He pointed to the increasingly insistent demand for a higher level of quality in brass castings, and regarded sand as the cardinal consideration in reducing the variables and effecting improvement. If unsound castings were dissected and the defects examined, he said, provided that primary precautions had been taken in the melting and casting, it was found that the largest number of defects was caused, directly or indirectly, by sand, which was the most inconsistent of all the materials with which the foundry had to deal. An examination of sand at the quarries revealed the striking fact that each seam had a basic dual character—each seam was a mixture of two or more sands, though rarely were there more than two, and he indicated a method of obtaining some measure of consistency by preparing sands with the highest number of grains of mean grain size.

Core sands were also dealt with at some length, and the author examined the various substances that could be used for binders, and methods of modifying core sands. The best means was, he said, to adjust the permeability by admixing more or less fine or coarse sand as required. Alternatively, and where possible, the length or cross-sectional area of the core might be altered. A further method was to raise or lower the gasifiable matter in the core by adjusting the quantity of binder used, or altering the baking time or temperature.

The paper served to emphasise the importance of sand control in overcoming many difficulties in the foundry.

A speaker in the discussion expressed a preference for the use of cores from a naturally bonded sand, for it would have similar properties as, say, a silica sand bonded with bentonite. But the author pointed out that the ability to add more or less bond brought the final product under control, whereas one could not intensify or reduce the bond in a naturally bonded sand except by very expensive processes.

Some Notes on Ingot Moulds.

A particularly valuable paper, which provoked a lengthy discussion, was one by Dr. T. Swinden and Mr. G. R. Bolsover, who presented a great many data concerning the use of ingot moulds in the works of the United Steel Companies, Ltd., collected over a period of four years, during which close observations have been made and the facts recorded. The moulds dealt with were the products of a number of manufacturers.

Costs of ingot moulds per ton of ingots and finished products were given, and the authors emphasised that an economy of 1d. per ton in the production of, say, 7,000,000 tons of ingots per annum represented a saving of approximately £30,000.

The influence of composition and structure of the mould metal on ingot mould life was discussed, and experiences with a number of alloyed cast iron ingot moulds were given. Results of experiments on German moulds of a type which were reputed to give much better life on the Continent than that normally obtained in this country were included.

Emphasis was laid on the importance of design, care in the use of moulds, and the influence of various mould facings. Information was given as to the manner in which moulds actually failed, and the possible means of improving their life. At the same time, the authors urged that moulds should not be used beyond the stage at which they were capable of producing ingots giving the maximum yield of satisfactory steel.

A point raised in the discussion, for the purpose of emphasising the importance of securing economy in ingot moulds, was that the costs per ton of ingot produced were greater with the high quality alloy steels than with the cheaper steels, for it was all the more important, it was suggested, with the high quality alloy steels to discontinue using a mould when its internal surface had become in any sense depreciated. But Dr. Swinden's experience, which he gave in reply to a question as to why the lives of moulds used for alloy steels should be shorter than those of moulds used for straight carbon steel, was that the most searching metal was dead soft rimming steel or free cutting steel.

In the course of discussion some criticism was levelled at the mould makers in respect of their alleged lack of support of the work of effecting improvements. Dr. Hatfield observed that there were none of the principals of ingot mould manufacturing firms present at the meeting, and only five or six representatives of such firms. He regarded the absence of principals as reprehensible, particularly having regard to the generosity of the United Steel Companies in allowing information to be published, and the care with which the authors of the paper had recorded the facts. It meant, he said, that that definitely practical problem was having to be tackled by the steel makers and not by the mould makers; the Iron and Steel Federation was finding money with which to pursue the technical developments in a practical way. The mould makers were not giving sufficient attention to the subject, they were not helping in a practical way, they were not putting money down for research, and they were leaving the steel trade to carry the baby all the time.

There were some, however, who championed the mould makers, and Mr. J. G. Pearce, the Director of the British Cast Iron Research Association, said he had found them quite prepared, and indeed willing and anxious, to supply the material on which investigation could be made. They had played their part through the Research Association.

With regard to the German moulds referred to, attention was drawn to the finer condition of the graphite in the iron, and the particular phosphorus content; but a suggestion made subsequently was that the care exercised on the Continent in the preparation of the moulds was an important factor. However, it was all a matter of economics, involving, among the other factors, the salvage value of the mould metal.

A hint was made by Dr. Hatfield that, if the Institute of British Foundrymen was so interested in that matter, the Ingot Mould Sub-committee of the Heterogeneity Committee might be persuaded in the future to present to the Institute the results of its investigations.

Steel Castings.

Dr. W. H. Hatfield, F.R.S., contributed a paper in which he surveyed briefly the various special steels applied to foundry practice, presented and correlated essential data needful for a proper working out of foundry technique, and discussed the applications and the properties determining those applications.

He dealt with steels in which alloying elements were added purely to increase strength, the rustless and acid-resisting steels, the heat-resisting steels, those having special magnetic properties, and the wear-resisting steels. Tables for the different types of steels, showing their analyses, heat treatment, and mechanical properties, were given.

The paper also included heating and cooling curves, typical micro-structures and physical data necessary to a foundryman, and it concluded with an appeal to every firm in the industry to support the Heterogeneity Committee of the Iron and Steel Institute and the British Iron and Steel Federation.

Research on Steel Castings.

Some suggestions for future research on steel castings were made in a paper by Professor J. H. Andrew (Dean of the Faculty of Metallurgy, University of Sheffield), who pointed out also how small was the amount of academic research and theoretical consideration given to steel castings as compared with the work carried out on steel ingots and forged material.

He mentioned as perhaps the greatest trouble experienced with castings contraction cavities and blow-holes. With regard to the former, Professor Andrew was in agreement with the view of the late Mr. J. H. S. Dickenson, that every section of a casting must be regarded as a separate ingot; thus, it was essential to provide fluid metal sufficient to supply each particular section as contraction was proceeding.

Research with a view to systematising the method of feeding and the arrangement of heads might well be undertaken, as well as a search for an element which, when added to steel, would reduce the fluid-solid contraction.

As to the formation of blow-holes, in so far as gas from the metal was concerned, it could be obviated by the addition of the correct amount of aluminium. Aluminium was known to make the running sluggish and to give rise to deeper pipe cavities; a high temperature of casting, coupled with feeder heads arranged correctly, might obviate that defect, however.

The question as to whether oxygen-free steel was desirable from the standpoint of its strength was an open one; recent research in Professor Andrew's laboratories indicated that the tensile strength of steel dropped very markedly when all the oxygen was removed. Provided the oxygen remained dissolved in the steel, it might possibly be an asset.

After indicating the importance of further research on facing sand, with particular reference to its composition, the author instanced some good results obtained with a facing sand entirely free from carbon, and mentioned alloy steel castings, suggesting that they might, under certain conditions, be oil hardened and tempered, and also, that there seemed no reason why air hardening subsequent to casting should not come into more general use.

Other matters for investigation were the atmosphere in which a steel was melted, and the effect of casting temperature upon fluidity. (There was, he thought, some reason for the view that the oxygen content of the steel was the controlling influence.)

Temperature Gradients in the Production of Steel Castings.

Mr. George A. Batty presented a paper, on behalf of the American Foundrymen's Association, on the influence of temperature gradients in the production of steel castings. The paper discussed in detail such problems as venting (rectangular vents were advocated), gating, pouring conditions, and so on; but, as the author pointed out, each casting presented its own peculiar problems, and, while castings might be classified in types, seemingly small variations affected materially the classification.

Castings.

A paper entitled "Castings," consisting of more than 120 pages, was presented by Mr. W. Machin (foundries manager), and Mr. M. C. Oldham (chief metallurgist), of Vickers-Armstrong, Ltd., Barrow Works. It is lavishly illustrated with drawings, photomicrographs, and photographs of various production operations.

The authors drew attention to the many variables associated with the production of castings, and dealt with the variables in moulds and cores, materials and metallurgical processes. The predominant factors, they concluded, were experience coupled with careful thought and study before commencing manufacture, and a definite line of co-operation with those concerned on the metallurgical side of the industry.

Many different types of castings were dealt with from the practical point of view, with the object of assisting the student and the foundryman.

Strickle Moulding of Large Castings.

On behalf of the Association Technique de Fonderie de France, a paper on the strickle moulding of large castings was presented by Monsieur H. Fabre (managing director), and Monsieur H. Dubois (foundry manager), of the Etablissements Bracq-Laurent, at Achicourt (pas-de-Calais). Whilst the authors did not attempt to give a precise definition of the general practice of strickle moulding, which were familiar already, they instanced several cases in which the application of strickle moulding presented characteristic features. Very simple castings were selected by way of example in order that the various working methods could be more easily followed. It would have been impossible to have given, within the narrow limits of a paper, all the details which complicated examples would have entailed.

German Ironfoundry Practice in Automobile Castings.

A third overseas paper—presented on behalf of the Verein Deutscher Eisengiesserein Giessereiverband—came from Germany. The author was Herr W. A. Geisler (Maschinen-und Armaturen-fabrik, G.m.b.H., Frankfurt-on-Main), who discussed German progress in piston rings, brake drums, and other automobile castings.

It was pointed out that piston rings for motor cars were originally made from sand-cast grey iron bushes, but as requirements in respect of quality became more exacting, research was directed to finding better materials and superior foundry processes. With the object of obtaining a fine-grained, wear-resisting piston ring, the single-ring casting process, as used in American practice, had been adopted almost universally in Germany. Piston rings made by the single-ring process had very small machining allowance, and the rings could be machined more economically than those made as bushes. That was not the determining factor, however; much more important and decisive was the material improvement in quality as compared with those machined from cylinders. The alloying of single-cast rings is beset with difficulties. The centrifugal casting process was much more advantageous in the case of alloyed piston rings, the rings being cast in bush form.

As to brake drums, a great disadvantage of using sheet steel was that drums so made expanded considerably when subjected to heavy brake pressure and heating, and went out of truth, and the brake lining frequently tore pieces of steel out of the braking surface. Cast iron was found to be far better than all other materials for the purpose; owing to its rigidity, it did not lose its shape, even under maximum heating conditions, and thus maintained a uniform braking effect. But its weight was a disadvantage, and a happy combination of the properties of sheet steel and of cast iron was incorporated in the Centrit brake drum made by Alfred Teves, of Frankfurt-on-Main, which appeared about two years ago. The author discussed the evolution of this drum, which consists of a sheet-steel back—the flange of which is provided with dovetail-shaped notches to facilitate intimate welding and obtain increased security—and a cast iron rim. The weld between the cast iron and steel is thoroughly intimate. He mentioned that a leading foundry for centrifugal castings in England is being equipped to produce the Centrit brake drum.

With regard to cylinder liners, the author said that in German engines, petrol as well as oil, liners were being used to an increasing extent. Hardened liners, however, had not been in great demand there; but completely satisfactory results had been obtained by the use of suitably alloyed centrifugally cast liners. For ordinary engines, centrifugally cast materials containing a slight proportion of chromium alloy had proved thoroughly satisfactory; but centrifugally cast liners alloyed with chromium and molybdenum were preferred for C.I. engines or engines subjected to high stresses.

High-grade cast iron was being used increasingly in motor vehicles.

Relationships in Cast Iron Test Results.

In view of the suggestions as to the unreliability of cast iron, owing to the variable factors operating in its production, some investigations made with a view to determining the extent of the variations and narrowing the uncertainty were discussed in a paper by Mr. G. L. Harbach, of Worthington Simpson, Ltd., Newark. The investigations were directed mainly to establishing relationships with a view to finding out the nature of the variables, and the effect of incorrect size on transverse breaking load. The relation between transverse and tensile strengths, and between tops and bottoms of bars; the effect of surface condition on the transverse result; the effect of span on modulus of rupture; the relationship between different sizes of test bars; and the effect of size on strength were studied.

The paper was prepared with a view to answering some of the queries concerning cast iron, and giving, where possible, quantitative values to the influence of various factors, the effects of which were generally appreciated, but apt to be over-estimated.

The author suggested that there was scope for publicity by manufacturers in the direction of improving the acquaintance of users with the properties of cast iron in general, and modern cast irons in particular. Probably that could best be done by a publication similar to that of the American Society for Testing Materials and the American Foundrymen's Association symposium on cast iron, compiled in collaboration with engineering bodies. It was essential, also, he said, that high-strength irons be included in a national specification, to show that British ironfounders were not backward as compared with those of other countries.

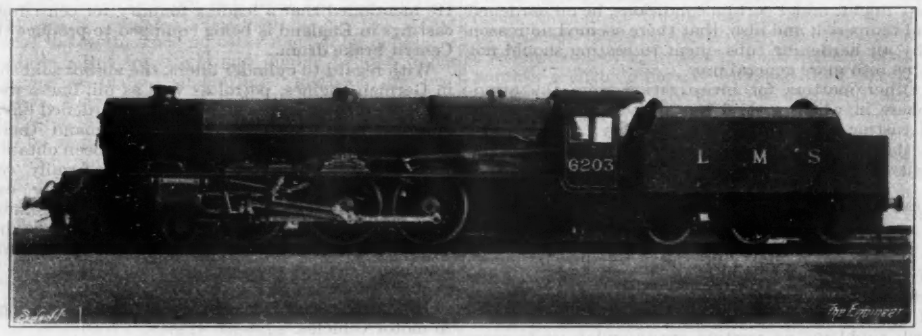
THE KING'S LANGLEY RAILWAY COLLISION.

The report of Colonel Mount on the collision of March 13th at King's Langley, L.M.S.R., was noted in our Seven-day Journal of July 12th. Except that four freight trains were involved; that their total weight was some 2730 tons, and that the wreckage extended for 120 yards, there was nothing to distinguish this accident from an ordinary collision between two freight trains brought about by irregular block working. Three features take this accident out of the ordinary. The line, of four tracks, on the 31 miles between Willesden and Cheddington has, for instance, recently been equipped with modern block signalling and interlocking between the lever of the signals and the block instrument. The second feature is that this safeguard was nullified by the signalman at King's Langley, who had his block instruments correctly recording the approach of the meat train and his home and starting signals at "clear" for it. Owing to a temporary defect in the vacuum brake gear on the locomotive the train was at a stand for six minutes between Nash Mills signal-box—1¾ miles north of King's Langley—and the latter place. The non-arrival of the meat train at King's Langley made the signalman there think that it had passed, so he telephoned to Nash Mill and asked "What have you coming up fast?" The other man replied that he had the milk train approaching and that led to the King's Langley signalman asking if the meat train had not been cleared. Nash Mills man answered that that was what he was waiting for. On the assumption that the meat train had passed and that he must give the train-out-of-section block signal for it preparatory to Nash Mills offering him the milk train, he had first to put his home signal lever to normal and he could then send the train-out-of-section signal. He had, moreover, to replace

his starting signal to "danger" before he could again lower his home signal, and that he did also. The result was that all the expense incurred by the railway to avoid collisions between following trains was thrown away. The third feature has reference to our remarks as recently as July 12th, on continuous track circuit in relation to the collision of June 15th at Welwyn Garden City. In his King's Langley report Colonel Mount says that "No equipment, however, short of continuous track circuit—which would hardly be justified—will ensure safety in the hands of an operator who has so little regard for, and interest in, the significance of his block working. . . ."

L.M.S. Four-Cylinder Passenger Locomotives.

DURING the present year the London, Midland and Scottish Railway Company expects to put into traffic a further ten 4–6–2 passenger tender locomotives of the



L.M.S. FOUR-CYLINDER EXPRESS ENGINE

"Princess Royal" class. These engines, which will be numbered 6203–6212 inclusive, are being constructed at the railway company's Crewe Works, and the first engine, No. 6203, named "Princess Margaret Rose," is just ready for traffic. Generally, these locomotives are modelled on the lines of the two earlier locomotives No. 6200, "The Princess Royal," and 6201, "Princess Elizabeth," built at Crewe in 1933, but certain minor modifications have been made as dictated by experience gained with their prototypes.

The leading dimensions as compared with the earlier locomotives are as follows:—

	Earlier locomotives, Nos. 6200 and 6201.	New locomotives, Nos. 6203–6212.
Four cylinders, dia. × stroke	16½in. × 28in.	16½in. × 28in.
Valve gear: Type	"Walschaerts"	"Walschaerts"
Travel	7½in.	7½in.
Coupled wheels, dia.	6ft. 6in.	6ft. 6in.
Boiler:		
Working pressure, lb. sq. in.	250	250
Fire-box heating surface, sq. ft.	190	217
Tube heating surface, sq. ft.	2,523	2,097
	2,713	2,314
Superheater, sq. ft.	370	653
Grate area, sq. ft.	45	45
Tractive effort, lb. at 85 per cent. boiler pressure	40,300	40,300

It will be observed that the principal changes are an increase in fire-box heating surface and, what is more noticeable, the great increase in the superheat. It may be taken roundly that every increase in superheat means a shorter time between overhauls—particularly of the pistons and piston valves. The C.M.E. has therefore to decide whether it is more economical to use a low superheat and keep his engines out for, say, 50,000 miles, or increase the superheat and bring the engines in at shorter periods. Mr. Stanier and his directors seem to have modified their views on this point, since the "Princess Royal" was built.

We illustrate the latest engine, but it is unnecessary to describe it in detail. The changes to which we have alluded are effected in the case of the boiler by the adoption of the now familiar forward projection of the fire-box to form a combustion chamber and the increase of superheater flues from sixteen to thirty-two. The superheater elements are of the bifurcated type from single downcomers, which are provided with spherical ball joints to the superheater header.

We may mention, in addition, that "Hoffmann" roller bearings are fitted to the axle-box journals of the trailing truck of five engines, the remaining five have plain bearings. Following recent L.M.S. practice all the axles are bored through from end to end.

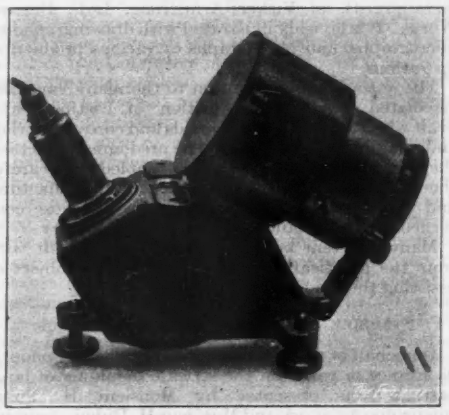
The sanding gear is of the trickle type, the sand being delivered in front of the leading and in front and behind the intermediate coupled wheels. The original engines had hand-operated gear; a departure has been made by providing a steam-operated gear. In addition, a water desanding apparatus is provided which comes into action simultaneously with the application of sand to the rails, so that after the engine has used the sand the rails are automatically cleaned with hot water to prevent interference with the track circuits.

The tenders are larger than those fitted to the two earlier engines. They are carried on six wheels with a wheel base of 15ft., and have a capacity for 4000 gallons of water and 9 tons of coal. On the left-hand side a cavity is arranged for the accommodation of the fire-irons. Hand brake apparatus is fitted to the tender wheels, in addition to the steam brake. Both the water pick-up and tender hand brake handles are arranged vertically, with bevel wheels to transmit the motion to its particular mechanism.

A Sensitive Vibration Recorder.

A POOL of mercury is an extremely sensitive indicator of vibration, as everyone who has used such a pool as an artificial horizon is only too well aware. C. F. Casella and Co., Ltd., of Fitzroy-square, London, have turned this characteristic to account in the vibration recorder illustrated herewith.

The diagram explains the principle. An electric lamp illuminates a thin horizontal slit, the image of which is brought by a lens to a focus on a sheet of bromide paper wrapped round the drum shown on the right, but first suffers reflection at a mercury surface. The drum is arranged to be revolved by clockwork, either once per hour or once in twenty-four hours at will. When there is no vibration a straight line is drawn round the drum, but as soon as any tremor is set up on the mercury this line is widened, the total amount depending on the severity of the vibration. The clock drum may be hinged out of the way and the spot of light examined visually in a ground glass screen. The clockwork is fitted with a stop and start mechanism, so that it is only necessary after loading



VIBRATION RECORDER

the drum with the bromide paper to set on the foundation to be tested and start the clock going to get the record. The lamp is run from electric mains in series with a carbon filament lamp or by a 6-volt accumulator. The mercury cistern is covered by glass plate so that the instrument can be transported without danger of spilling the mercury. There is a shutter which closes the slit of

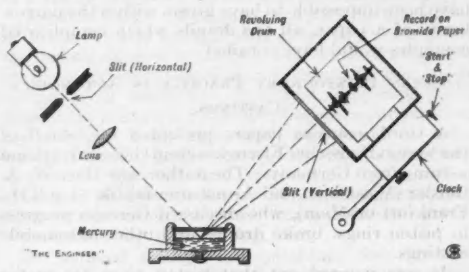
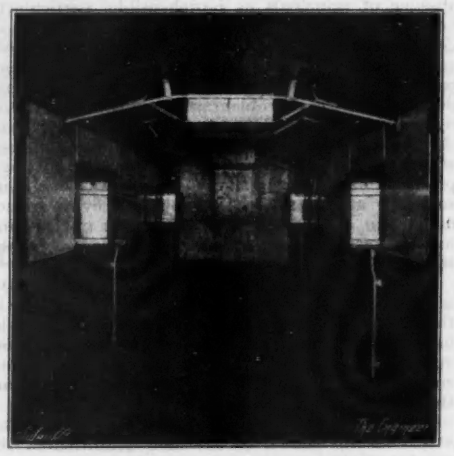


DIAGRAM OF VIBRATION RECORDER

the containing case of the revolving drum, so that the drum may be removed and taken to a dark room for development of the film.

Insulated Milk Vans for L.M.S. Railway.

THE L.M.S. Railway has recently completed at its Derby works two insulated milk vans specially designed for the conveyance of milk in churns. Their outside dimensions are 31ft. by 8ft., and they will carry 6 tons. The vans are mounted on steel underframes of the standard design for six-wheeled carriage stock, equipped with vacuum brake, hand brake with outside levers, through steam pipe and screw couplings. Two pairs of insulated double doors with a 5ft. opening are provided on each side. They are fitted with cam action fasteners and the joints are sealed with I.R. tubing and "Rubo" gaskets. New features in the construction of the body include the special arrangement of the pillars, rails, and roof sticks, whereby the framing members and roof sticks carrying the outer panels and roof boards are separate from those carrying the inside panels and ceiling. With this arrangement, a more complete insulation from the effects of the outside temperature is obtained. The body side panels are of multi-ply, ⅛in. outside, ⅛in. inside, with a space of 3in. between. The pillars and rails are, with the exception of the door standing and corner pillars, 3in. wide by 2in. thick, leaving a space of 1in. between each member and the panels opposite to them, and are arranged alternately and apart from each other. Corrugated sheets of "Alfol" are arranged in the spaces thus provided, and the insides of the panels and framework are lined with Bitumastic paper. The roof and floor are constructed on the same principles. For hygienic purposes corners have been obviated where possible; and the interior of the vehicle is lined up to a height of 3ft. 2in. with 24 S.W.G. stainless iron, the top of the panels being covered with a ¼in. convex galvanised iron moulding. The cooling apparatus inside the van consists of six wet ice bunkers, spaced three on each side, and three Drikold bunkers to contain solid CO_2 fitted close up to the ceiling, the interiors being connected by ¾in. bore galvanised pipes and brass outlets to the insulation space in the body side and ends. The special construction of the body framework permits a complete circulation and allows the air in the



INTERIOR OF L.M.S. MILK VAN

insulation spaces to come into contact with the cooling gas, thus further assisting the Alfol insulation.

Care was taken in the construction of the vehicles to prevent as far as possible bolts securing ironwork on the body passing from the outside to the inside, and where this is not possible, the heads are covered.

The insulated milk vans have been designed by Mr. W. A. Stanier, chief mechanical engineer of the L.M.S. Railway, to whom we are indebted for this description as well as the photograph.

SIXTY YEARS AGO.

FROM a paper entitled "Bursting of Water Supply Pipes in Winter," which Mr. W. H. Bailey had read before the Society of Municipal Sanitary Engineers, and which we reprinted in our issue of July 16th 1875 our readers might doubtlessly have expected to obtain some information as to the reason why water pipes burst in cold weather. Actually very little indeed was said on that subject. The usual explanation, namely that the freezing of water causes it to expand and apply a pressure to the pipe which it cannot support, was assumed, apparently, to be indisputable and Mr. Bailey without discussing it dealt very briefly with the use of elastic diaphragms, rubber balls and other devices which had been used, without effect, to provide room for the water on freezing to expand. His own suggestion to prevent the trouble consisted simply in the provision of a small gas jet beneath a short cylinder connected in parallel with the supply pipe at a point close to its entry to the house. Without passing any opinion on the efficacy of this device we would ask the modern reader whether he really knows why water pipes burst in frosty weather. Before he accepts the familiar explanation mentioned above he may be advised to look up the figure for the expansion of water when it passes into ice and to study the elastic properties of lead, iron or the other metal of which the pipes are composed. But to return to Mr. Bailey. The bulk of his paper was devoted not to the bursting of pipes as implied in his title but to the bursting of domestic boilers. Except for the fact that the inlet and outlet pipes might be frozen at the time when the fire was lit there was no particular reason why he should have mentioned winter time in his title. He was primarily concerned, when we get down to the root of his remarks, with certain bad practices then commonly followed in domestic engineering which led to explosions as frequently in summer as in winter. These practices turned upon the assumed necessity for fitting the circulating system in some way or other with taps or cocks so arranged that the boiler could be completely isolated from the rest of the system when it was desired to empty it for cleaning or inspection. The inevitable result was that all over the country explosions, frequently fatal, were constantly occurring as a result of the boiler having been lit with the isolating cocks accidently closed. Mr. Bailey argued that the fitting of safety valves in the circulating system of domestic boilers should be made compulsory.

Windmill Drainage in the Bedford Level.*

By H. C. DARBY.

WHEN, in 1651 and 1652, the certificates of adjudication were issued which adjudged the Bedford Level, in the southern part of the English Fenland, "to be dreyned in such sort as by the acts of parliament is appointed to bee dreyned," it appeared as if an end had come to many tedious and intricate proceedings. Great success seemed to be following upon the works of the drainers. Cultivation was introduced on lands which, as far as record went, had never before known a plough; and the faith of the speculators in the economic possibilities of the late fens seemed to be justified in all ways. Thomas Fuller in 1655[1] was loud in his praises. As he said, "the best argument to prove that a thing may be done is actually to do it," and the same praise is evident in Sir William Dugdale's "History of Imbanking and Drainage," of 1662.

But, despite many praises, it was soon evident that all was not well in the Bedford Level. The immediate consequences of the draining held forth a promise that was not to be fulfilled for many a long year. Some of the complaints of the time were summarised in the General Drainage Act of 1663: that the draining of one place had made worse the lands in other places; that there were many discrepancies in the allotments of land between owners, commoners, and townships; and that the maintenance of the Level involved a clash with the interests responsible for navigation. But, as the seventeenth century drew to a close, these administrative and legal difficulties were being overshadowed by natural difficulties which brought the very success of the drainers near to disaster. Without some idea of the nature and the magnitude of these physical difficulties, it is impossible to understand the rapid deterioration of every scheme of drainage, and to appreciate the engineering controversy that has raged round the Bedford Level up to the present day.

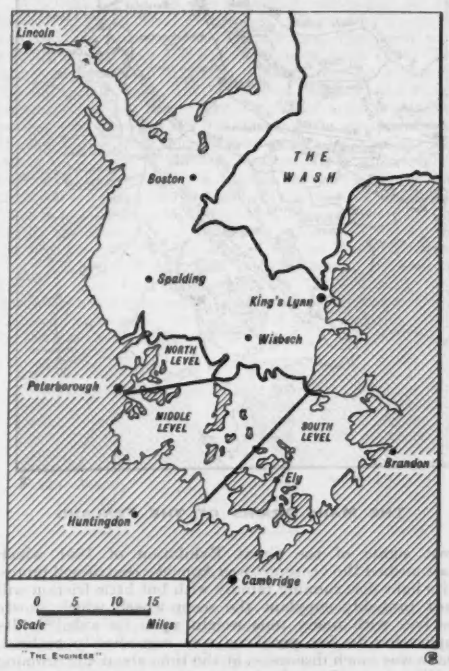
OUTFALL DIFFICULTIES.

The principal feature in any river is its natural gradient or "fall." Together with the volume of the water, this controls the speed of the current and its power of scouring out the river bed. The greater the gradient, the more rapid the passage of water, and the better the channel. The "fall" of any river can be artificially increased by shortening its course or by dredging. Normally, the natural gradient is sufficient to ensure a satisfactory outfall; the force of the current can grind a bed for the waters, and so keep the channel clear. But in the Fens, conditions were far from normal. For 40 miles from the mouths of the rivers, the gradient was very slight, and therefore the current and the resulting "scour" were sluggish, so that the natural river beds tended to be wide and shallow, as well as very winding. Finally, there were strong tides to be reckoned with, bringing in unusual quantities of silt. In the Ouse, the tide penetrated as far as Earith and beyond; in the Nene, its influence was felt as far up as Guyhirne when the Horseshoe Sluice below Wisbech was open. The downward force of the fresh waters was thus no match for the strong tidal flow twice a day. The river beds were only large enough to contain both fresh and tidal waters in dry seasons,[2] and the slow ebb tides and slower fresh water currents lacked the necessary force to dislodge the immense quantities of silt deposited at every tide. Consequently, the beds of the estuaries were continually being raised, and the fresh waters found great and greater difficulty in forcing their way to sea. At the time of the general reclamation, the outfalls of the Welland and the Nene were almost useless, and the state of the Ouse above and below Lynn was anything but satisfactory.

About the general scheme of the drainage there had been two principal schools of thought. One party, headed by Vermuyden, was in favour of shortening the courses of the main rivers by straight cuts, thus increasing their gradient; the other party advocated the deepening, clearing, and embanking of existing watercourses. With the triumph of Vermuyden, the former plan was adopted, and the principle was established that the old natural channels should be abandoned, where expedient, in favour of new straight cuts.[3] The basis of Vermuyden's plan, set out in his "Discourse Touching the Drayning," of 1642, was briefly this: That distinction should be made between the upland waters and the water actually falling upon the Fens. The former were to be conveyed through the Level in wide straight cuts, embanked to prevent overflow, to the nearest outfall; the downfall water was to be conveyed to the outfall as far as possible in separate drains. This separation was intended to prevent the swifter upland waters from overriding the more sluggish fen waters in the main drains and rivers, and so causing floods in the minor drains. As far as the separation was concerned, the plan was carried out. The upland waters were in the main confined to Morton's Leam and the Hundred Foot River. But, unfortunately, all the waters of the Middle and South Levels,[4] both upland water and local rainfall, were directed to a single outfall towards the King's Lynn estuary; and, moreover, they were organised in such a way that the waters of the Hundred Foot River had precedence of outflow.[5] Further, there have also always been a number of brooks running down from the edge of the upland into the Fens, and overflowing easily in wet seasons, to become a source of local damage. No attempt was made to intercept these streamlets by an adequate catchwater drain to convey their contents into one or other of the main channels; consequently, even the severance of upland and fen waters was only partially effected.[6]

A much more serious criticism, however, was the fact that Vermuyden's scheme, and the subsequent reclamation, stopped near the Salter's Lode and Guyhirne, and did not extend into the zone of outfalls. Long before the project of general reclamation was mooted, the decline of the river outfalls was known to be the chief reason for the flooding of the Fens; and, from 1579 onwards, every proposal emphasised the need of starting improvements at the sea and working upwards. The Commissioners of Sewers, in 1579, advocated the opening of the Shire Drain by working from the sea up to Clows Cross;[7] and, again, in 1609, it was decided that Popham's scheme should be abandoned and all energies concentrated upon improving the Wisbech outfall.[8] A pamphlet of much the same date stated that the neglect of the "laws of sewers" had led to the silting of Wisbech River, which, in turn, prevents any improvement of the internal drainage.[9] Vermuyden himself laid down most emphatically in his "Discourse" that if the Middle Level was to be immune from floods of the Nene, the outfall of Wisbech River must be widened and deepened. Finally, Colonel Dodson, who in 1665 commented on the completed work, remarked: "In all draining we have respect to our outfall, for if we cannot be master there, all other endeavours signifie nothing."[10]

But, when Dodson wrote, the omission of adequate outfall works had not yet been revealed in all its weaknesses. For a period, while the drains were in their first state of perfection, the increased speed of the waters passing down to Lynn and Wisbech did improve the estuaries of the Ouse and the Nene. But, in a disturbingly short time, a rapid deterioration was noticed. The waters of the Middle Level, collecting into the Old Bedford River and Well Creek, were liable to be overridden by the Hundred Foot River in times of pressure.[11] This obstruction of the outfall caused a high level of water in the internal drains, and placed a great strain on the defences of the Middle Level just when it was essential that the waters should get away as quickly as possible. The bed of the Hundred Foot River had been laid 8ft. higher than that of the old Ouse, with a vertical drop at the northern end. Combined with the sluices at Denver, and with those at the mouths of the Old Bedford River and Well Creek, this difference of level meant that, for several hours each



THE FENLAND SHOWING EXTENT OF BEDFORD LEVEL

day, the tidal waters stood stationary on the very threshold of the Level, depositing vast quantities of silt. The high Hundred Foot bed prevented the tide from rising as far as it had done in the Ouse, and part of the ebb tide "scour" was thus forfeited. Increased deposits of silt accumulated in the Lynn River, and within a short time the drop from the bed of the Hundred Foot to the outfall channel had disappeared, and there were several feet of silt lying against the sluice sills.

There were further difficulties. The large and powerful navigation interests involved in the Fens always insisted on the maintenance of adequate levels of water in the arterial drains for uninterrupted passage of boats and barges. The ideal of every fenland engineer was to keep the level of water in the internal drains low enough to contain a sudden flood at any time, and consequently this compulsory height of water became a severe, and sometimes unnecessary, handicap. The drainage was further handicapped by the existence of a very large number of locks on these drains, each acting as a separate check on the passage of waters.

THE LOWERING OF THE LEVEL OF THE FENS.

But there were yet other difficulties of a more fundamental nature. Neither Vermuyden nor any of the other drainage engineers foresaw, when they planned and executed their schemes, that, as soon as they started to drain the Level, the surface of the peat fen would become rapidly lower. This lowering was due, in part, to the shrinkage of the peat as it dried, but also to the wasting away of the drying peat surface, owing to bacteriological decomposition.[12] Indeed, the better the drainage, the more rapid the wastage. The result of this disconcerting characteristic was that, within a comparatively short time from the completion of the reclamation, many of the main channels flowed at a level higher than that of the adjoining surface; and so the fenland waterways got shallower and less efficient This extraordinary paradox can still be seen along most of the Fen rivers, where the heights of the barrier banks are far greater from the outside than from the beds of the rivers. The spongy nature of the banks, always a problem in such light porous soil, became a constant menace to the efficiency of the drainage, and the subsidence of land threatened the security of buildings and embankments. Moreover, the beds of the outfall channels, never very low, soon came to be almost as high as the lowest parts of the Fens.[13] The minor drains, too, lost the depth. Thus the difficulty of getting rid of the downfall water increased annually.

There were other difficulties also. Factions on the Board, and large arrears of taxes, meant that essential works for maintenance were not undertaken. Owing to the nature of the soil, the banks along the new cuts crumbled away very rapidly, and constant supervision was necessary to prevent rushes and weeds from choking the drains. Silts and gravels soon formed in their beds, combining with the shrinkage to render the rivers even still less effective. Above all, the individual owners of reclaimed land were very slow in providing minor drains to carry the water from their fields into the old natural streams or to the new drains. Owing to financial difficulties, the responsibilities of the Corporation of the Bedford Level could not extend beyond the maintenance of the two great upland channels with their "washlands,"[14] and the main internal drains, and these alone could not suffice for complete drainage. Even where minor drains were made, they soon flowed at a lower level than the channels into which they discharged.

The only remedy for such conditions was to pump the water from dyke to drain and from drain to river. In fact, the introduction of pumping engines was the critical factor that saved most of the Fens from reinundation. Some such engine may have been in use before 1600[15] and, at any rate during the early part of the seventeenth century, there were notices[16] of patents for engines "for raising water and draining surrounded grounds." In Hayward's "Survey of the Fens," in 1635–36, reference was made to an "Ingine bank at Oxney," which is mentioned again in the St. Ives "Law of Sewers," in 1638.[17] Walter Blith in his treatise[18] instructed—

> "That having well provided against the waters of bordering Fens, find out the lowest part of all they Lands, and thither draw a good substantial Master-drain through all thy Lands, and there plant a water-Engine, which may either be wrought by the wind, or by the strength of horse, yeen possibly by the strength of two or three men."

Elias Ashmole, in 1657, observed that "the Windmills about Wisbech stand upon Tumuli,"[19] and it is evident that during the latter half of the century such expedients were being increasingly used. At the April meetings of the Corporation in 1679 at Ely it was—

> "ordered, that for the better and speedier cleansing and scouring of draynes, the four surveyors of the Level do forthwith buy each of them a mill, made for that purpose, and pay for the same out of money allotted for their respective Levels."[20]

Whether these particular "mills" were engines for raising water or for clearing weeds and mud, the fact remains that pumping was becoming increasingly common. Nor did such expedients pass without opposition, for a mill sometimes worked to the prejudice and drowning of neighbouring country. At the Board Meetings of the Corporation, discussion about the setting up of mills became more and more frequent. The Corporation frequently resented the employment of such pumps, because, in throwing up water, they endangered the banks of the drains or caused an overflow. For some years they were frequently condemned and ordered to be pulled down. Yet, despite complaints, the fact was that mills provided the only means of clearing the water, and, as the seventeenth passed into the eighteenth century, mill drainage became more and more prevalent. By 1726 the state of the rivers and interior drains was so bad that the Corporation found it impolitic to resist local efforts at improvement any longer, and in the following year the first subdistrict was established at Haddenham in the South Level. A private Act of Parliament authorised this district to set up a pump, and to raise funds by rates within its boundaries, for securing and maintaining immunity from floods. This precedent was followed at intervals through the next 150 years by other groups of landowners, and these supplemented the work of the Bedford Level Corporation in looking after the main drains. In this way did the whole of the Bedford Level come to consist, almost entirely, of small sub-districts, each dependent for its internal drainage upon small cuts leading to a central drain, which discharged its water by pumping into one of the larger arterial cuts.

Each of these statutory districts had its own authority, with full control over the internal drainage of the district with wide powers of local taxation, and with limited powers of negotiation with adjacent bodies over matters of mutual concern. Liability to a district drainage rate, of course, in no way freed land from liability to the general rates levied by the larger authorities. The cost of the reclamation and of subsequent improvements has been far greater than is generally realised. Most of the members of the first reclamation company went bankrupt; and shares in the second corporation were divided and subdivided to meet the demands for capital. Large debts were contracted from time to time after the initial reclamation for extensive operations, and interest on them added further to the demands on the income of the Corporation. Rates were constantly in arrears, in spite of drastic penalties, and the difficulty of guaranteeing a revenue, at once adequate and certain, did much to produce the long period of inactivity with which the history of the Bedford Level Corporation closed.

THE EAU BRINK CUT AND KINDERLEY'S CUT.

In the meantime, other difficulties had arisen. The Bedford Level Corporation had been successful in retaining the Denver Sluice against much opposition from those interested in navigation, particularly from the townsfolk of King's Lynn. But its destruction came by the hand of Nature for, in 1713, a combination of high tide and violent floods undermined the sluice and wrecked it. It remained in this condition for some years. The obstruction to navigation was thus demolished, but the effect of that abolition upon the southern fenland was critical. The whole confluence of waters near Salter's Lode now flowed with the tide up the old course of the Ouse, which had not yet silted to the height of the Hundred Foot River. The South Level was reduced at times almost to a lake, and this state of affairs continued at every unusually high spring tide.[21] Denver Sluice which had caused so much discussion during its lifetime was to cause even more after its disappearance. There were petitions and applications and memoranda between the Bedford Level Corporation, the individual proprietors, and the Corporation of Lynn.

The renewed deterioration of the Ouse estuary produced the great outfall controversy which, after the lapse of

* British Waterworks Association (Incorporated).

two centuries, is still full of vigour. As Badeslade wrote, in 1726 :—

> "All parties acknowledge the misfortune, for they all suffer; but all do not agree in the cause of this general calamity, nor in the method that must be put in practice to relieve them; but all agree and declare, that if something be not done, this country will be rendered uninhabitable."[22]

During the next half century there was much discussion about the relative merits of sluices. At any rate, between 1748 and 1750, Denver Sluice was rebuilt. In the following year, 1751, however, Nathaniel Kinderley's "State of the Navigation of the Towns of Lynn, Wisbech, Spalding, and Boston," introduced a new element into the dispute. Kinderley declared that the primary cause for the unsatisfactory result of Vermuyden's enterprise was not Denver Sluice nor the height of the Hundred Foot River, but the wide, shallow, circuitous river below Salter's Lode. He therefore suggested the cutting of a new channel from the Eau Brink near St. Germans to the lower end of Lynn harbour. This would cut out a 7-mile detour, thus improving both the gradient and the scour of the river, and the greater velocity so obtained would enable more water to be run off.[23] After much discussion, the first Eau Brink Act was passed in 1795, but the Napoleonic Wars interfered with the progress of the work, and the expense proved far greater than had been anticipated. In 1809 John Rennie issued a report [24] giving a detailed account of the defects in the current system of drainage, and suggesting improvement. The obstructed state of the outfall, the incapacity of the neglected drains and rivers to contain the fresh waters, the height of the main rivers above the fen, were the main weaknesses in the Middle and South Levels. His remedies were the Eau Brink Cut, a catchwater drain from Stanground round the edge of the uplands to Mildenhall to intercept the brooks,[25] and the thorough reconditioning of the internal drains. The first, at least, was accomplished after numerous additional Acts had been passed, and in 1821, seventy years after it was first proposed, the Eau Brink Cut was opened. It had an immediately beneficial effect on the South and Middle Levels, but it was not sufficient by itself to perfect the drainage.[26] With the continued wastage of the peat, how could it?

During this time the state of the Nene outfall was also causing anxiety, and attention was repeatedly drawn to the condition of the estuary below Wisbech. The river terminated about 4 miles below the town, after running very irregularly through salt marshes, changing its direction frequently, and some times splitting into two or three branches. Charles Kinderley, about 1720, urged that embankments be made to confine the stream to one course through the sands as far as St. Peter's Point,[27] 7 miles below Wisbech. He hoped that by these means a fall of something over 5ft. would be obtained. His suggestions were adopted by the Bedford Level Corporation, which entered into an agreement about the matter with the town of Wisbech. The work was started, but before its completion the Wisbech authorities, fearful for their habour and its navigation, filed a petition in the Chancery Court and obtained an injunction to stop the undertaking. Considerable litigation followed, and the work remained suspended for fifty years. The project was revived in 1751[28] by Nathaniel Kinderley, the son of the original proposer, but it was not until 1773 that the abandoned work was extended. The finished channel was called Kinderley's Cut, in memory of its first proposer. Its effects were immediately beneficial, but the drainage was still far from being perfect. Wastage of the peat surface continued unceasingly.

Nor did the new century bring any satisfactory solution to the problem of the outfalls. Throughout the nineteenth century there were reports advocating remedies for the Wisbech River, [29] and various improvements were carried out in the outfall after the opening of Kinderley's Cut. In the years 1753, 1848, and 1862 Acts were passed for improving the river itself, but a report, drawn up in 1909, still spoke in no measured terms of the neglected state of the river between Peterborough and the sea.[30]

The Eau Brink Cut, too, did not produce as great an improvement as had been expected, and the problem of running off surplus water remained very pressing.[31] In 1836 Sir John Rennie proposed that the western half of the Level should drain by Bevill's Leam and the Twenty Foot Drain into the Nene at Guyhirne, to reduce the volume of water requiring passage at Salter's Lode,[32] but though this sounds reasonable, it was not acted upon. Before 1842 a certain Mr. Laurence had brought forward a plan for abandoning the existing outfall entirely, and for cutting a new main drain from the Sixteen Foot River to the head of the Eau Brink Cut, through Marshland. After much discussion, a Bill was passed authorising the proposed cut, and the Marshland drain was completed in 1851 to give the Middle an adequate run-off. But even this, in time, was to prove unsatisfactory.

THE DISAPPEARANCE OF THE WINDMILL.

In the meantime, the number of windmills in the Level steadily increased. Thomas Neale, dealing with "The Ruinous State of the Parish of Manea, in the Isle of Ely," in 1748, declared that

> "there are now no less than 250 in the Middle Level. In Whittlesey parish alone, I was told by some of the principal inhabitants there are more than fifty mills, and there are, I believe, as many in Donnington with its members. I myself, riding very lately from Ramsey to Holme, about six miles across the Fens, counted forty in my view."

But, at best, a windmill was a wayward co-operator, at the mercy of wind and gale and frost and calm. It was never powerful, and it never provided a satisfactory solution to the problem of clearing water from the drains And as the peat surface continued to shrink and waste away, the windmill became less and less effective. It is true that there were improvements in the wind engines, but, even so, wind-driven pumps were proving inadequate. In 1820 the first Watt engine was applied to work a scoop wheel upon Bottisham Fen, and others followed soon after. One of the pioneers in the application of steam engines to fen drainage was Joseph Glynn,[33] who wrote in 1838, summing up his work: "I have not only caused 'two blades of grass to grow where but one grew before,' but I have had the pleasure to see abundant crops of wheat take the place of the sedge and the bullrush." Thus was "the swamp or marsh exhaling malaria, disease, and death," "converted into fruitful cornfields and verdant pastures." His example spread during the years that followed, and with that spread one of the most characteristic elements in the landscape of the fenland, ever since the drainage of the Bedford Level, was doomed to disappear.

J. A. Clarke's summary of the situation in all the Fenland in 1852 is instructive :—

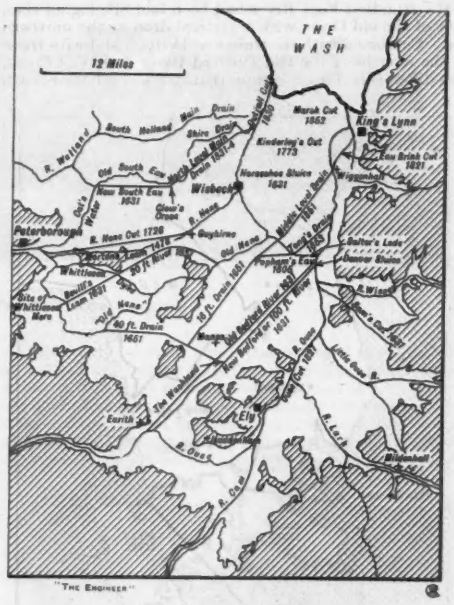
> "At present there may be about 50 mills in the Lincolnshire part of the Level, and perhaps 170 in the Bedford Level and adjacent fens, or a total of 220. The number of steam engines may be estimated at 17 in the Lincolnshire part, varying from 10 to 80 horse-power each, and upwards of 47 in the remainder of the Level. They lift water from 6 to 16 or even 20 feet; and the area of land which they drain may be computed at not less than 222,000 acres. This rapid application of an unfailing though costly power to the performance of duties hitherto entrusted to the changeful and often disastrous caprices of the wind is a striking example of agricultural progress."[34]

But, although survivors lingered on, one by one the anachronisms fell into disuse.

There were still further changes at hand. One of the great sights of the Great Exhibition of 1851 which "astonished the visitors" was Appold's centrifugal pump. "Its light disc running rapidly with but little friction will most probably supplant the scoop-wheel, which slowly revolves with many tons weight upon its axle."[35] Its application to fen problems was immediately realised. There was much discussion at the time about the draining of Whittlesea Mere, the last great stretch of open water in the Level, and the inventor of the new pump was commissioned to devise an engine for this purpose.

> "The wheel 4½ feet in diameter, worked by a 25 horse power engine, lifts 74½ tons of water 5 feet high, or 101 tons per minute between 2 and 3 feet high."[36]

In this way there disappeared the last remaining large stretch of water in the Fenland: "the wind, which, in the autumn of 1851 was curling the blue water of the lake, in the autumn of 1853 was blowing in the same place over fields of yellow corn."[37] The change marked the complete triumph of the steam-driven mill. But neither the application of steam, nor any other improvement in technique, could stay the unceasing lowering of the peat surface.



THE MAIN DRAINS OF THE FENLAND

BIBLIOGRAPHY.

[1] "History of the University of Cambridge," Section V. Fuller comments at length upon the benefits of the new régime. For further eulogy, in 1685, see also Sir Jonas Moore: "History or Narrative of the Great Level of the Fens called Bedford Level: with a Large Map of the Said Level as Drained, Surveyed, and Described."

[2] Hence the need for "wash-lands" along the tidal channels of the Ouse and the Nene, above the estuary. The floods were thus kept within definite limits, and could be run off at convenience.

[3] The improved "fall" in the rivers which was expected to result from the new system of drainage was, in turn, expected to have a very beneficial effect on the state of the estuaries of the Ouse and the Nene. The greater velocity ought to increase the scouring power of the fresh waters, and dislodge a greater quantity of silt. For a short time there actually was a marked improvement.

[4] The Level was divided by Vermuyden, in his treatise, into three parts :—

(1) North Level, from the Glen to Morton's Leam.
(2) Middle Level, from Morton's Leam to the Old Bedford River.
(3) South Level, the remainder of the level.

Later, however, the North Level did not extend beyond the Welland.

[5] Well Creek, the Old Bedford River, and the Old Ouse, outfalls for the surplus fen water of the Middle and South Levels, were sluiced against the tide. The sluice doors were opened when the level of water on the seaward side fell to a certain height. When there was a great volume of water passing down the Hundred Foot, the level against the sluice doors never fell low enough for them to be opened, even at low tide. This circumstance would take place during wet periods, when the Fens were more liable to be water-logged than at other times, and ought to have had a rapid run-off.

[6] Lord Gorges, Survey-General to the Corporation, pointed this out in 1685. (Appendix to Badeslade, "History of the Ancient and Present State of the Navigation of the Port of King's Lynn, and of Cambridge," 1726, pages 131–35.)

[7] Deposition by Commission into Exchequer. E. 134, 1579 Mich. 33. (Public Record Office, London.)

[8] Seventeenth Century MS., volume on Draining, page 147. (Bishop's Muniment Room, Ely.)

[9] *Ibid.*, pages 185–87.

[10] "The Design for the Perfect Draining of the Great Level of the Fens," 1665.

[11] Without the sluices at Denver, the waters of the Hundred Foot River would thus turn up the course of the old Ouse towards Littleport, and so flood the South Level.

[12] The extent of the diminution can be seen from observations made by Major Gordon Fowler, near what was the south-west edge of Whittlesea Mere. "Shrinkage of the Peat-covered Fenlands," *Geographical Journal*, Vol. LXXXI, page 149.

[13] Badeslade, *op. cit.*, page 93. In 1725 low-water mark in Lynn River was 1ft. higher than the surface of the Fens.

[14] The Nene had been organised in a similar way to the Ouse. Morton's Leam corresponded to the Old Bedford River, Smith's Leam was made parallel to it, and a strip of land was left between the two for the waters to "bed into" in times of flood.

[15] State Papers, Domestic Series, Elizabeth. CXXVII 57; and S. P. Eliz, CCXLI 14. (Public Record Office.) Such engines must have consisted of a scoop wheel propelled in some way, possibly by horses.

Before 1616 William Stermyn, of Elm, had "on Engyne or Worke for the drayning of certaine Surrounded Landes," and "layde out of the purchase of the sayd Engyne or Worke and for the keeping dressing useing and ordering the same by the space of one whole yeare the sum of fortye and fyve poundes." Chancery Proceedings, Case 3, Bundle 290, No. 47 (1596–1616), P.R.O.

[16] *e.g.*, S.P. Jas. I, XC 103 (1617), and S.P. Jas. I, CXXII 57 (1622).

[17] See S. Wells "History of the . . . Bedford Level" (1820), Vol. II, pages 210 and 337.

[18] "The English Improver: Or a New Survey of Husbandry." This was enlarged in 1652 as "The English Improver Improved." The quotation is taken from the chapter on "Fen-drayning," page 45 *et seq.*

[19] "Observations in My Fen Journey, begun 19th May, 1657." Ashmolean MS. 784 (Bodleian, Oxford).

[20] Conservators' Proceedings, Ely Series (Fen Office, Ely). *Sub anno* 1679.

[21] Badeslade, *op. cit.*, page 87. November–December, 1720. Waters of the Hundred Foot ran up the Ouse for twenty days without intermission. Badeslade, it should be stated, was on the side of those interested in navigation.

[22] Badeslade, *op. cit.* Preface.

[23] Because the water level at Salter's Lode and below would be lowered, so the sluices guarding the outfall of the Fen waters could be opened for longer periods.

[24] "Report and Estimate on the Improvement of the Drainage and Navigation of the South and Middle Levels."

[25] "It is worth the exercise of some ingenuity to keep upland and low-level water quite apart, as it will be found that the low-level drains of an ordinary marsh or fen are generally taxed to their utmost capacity during exceptionally wet periods, and that the addition of water from the rapidly discharging hill areas may make all the difference between bank-full drains and inundation of the level."

[26] Telford and Rennie, "Report on the Eau Brink Cut Two Years After the Opening," 1823.

[27] "The Present State of the Navigation of the Towns of Lynn, Wisbech, and Spalding," Published anonymously in 1721, but afterwards revealed to be by Kinderley.

[28] "The Ancient and Present State of the Navigation of the Towns of Lynn, Wisbech, Spalding, and Boston."

[29] *e.g.*, John Rennie, 1814; Sir John Rennie, 1836; J. M. Rendel, 1849; Stephenson and Bidder, 1858.

[30] "Report of Royal Commission on Canals and Inland Navigation," 1909 (Final Report), page 27.

[31] Several other improvements were made in the outfall channel. The Act of 1846 set up the Norfolk Estuary Company. Intended originally to recover land from the Wash, since 1853 the primary object of this body has been the maintenance of an extension seawards of the Eau Brink Cut, in spite of great physical and financial difficulties. Training walls have been built to try to induce the Ouse estuary to keep a defined channel among the shifting sand banks of the Wash. The further extension of this defined channel and the cutting off of another bend in the original course of Lynn River were the two most important works proposed by the Ouse Bill of 1927, which was defeated in Committee. As this project showed, the problem of an outfall for the fen waters was by no means solved.

[32] "Report on the Improvement of the Navigation of the Nene and the Drainage of Part of the Middle Level."

[33] Joseph Glynn, "Draining Land by Steam Power," in "Transactions," Royal Society of Arts, Vol. LI (1838), pages 3 *et seq.*

[34] J. A. Clarke, "Fen Sketches" (1852), page 249.

[35] J. A. Clarke, *op. cit.*, pages 247–48.

[36] J. A. Clarke, *op. cit.*, page 249.

[37] See W. Wells, "The Drainage of Whittlesea Mere," *Journal*, Royal Agricultural Society, First Series, Vol. XXI (1860), pages 134 *et seq.*

BRITISH STANDARDS INSTITUTION.

All British Standard Specifications can be obtained from the Publications Department of the Institution at 28, Victoria-street, London, S.W.1. The price of each specification is 2s. 2d. post free, unless otherwise stated.

RADIO-INTERFERENCE SUPPRESSION DEVICES.

No. 613—1935. This specification deals with the rating, performance and testing of condensers, inductors, and resistors used in the construction of interference suppressors. In an appendix are given numerous diagrams of connections and schedules of component values, which have been found satisfactory in practice for the suppression of interference from various types of machines and appliances. It is intended that this specification shall be followed by a general specification dealing with the permissible limits of radio interference and methods of measurement of such interference.

UP to the end of June, 1935, the "Flying Hamburger" express oil-electric railcar of the German State Railways has covered a total mileage of 226,840 miles. During 25½ months in scheduled service, from May 15th, 1933, to June 28th, 1935, the railcar has covered 217,214 miles. The distance between Hamburg and Berlin is 178 miles and the above figure of 217,214 miles therefore represents 607 single journeys. The availability of the railcar in service has been 95 per cent. We are informed that thirteen more railcars have been ordered from the Wumag, of Goerlitz, some of which have already been supplied, and others will be completed in the near future; each of these units is fitted with two Maybach engines of the 410 h.p. type.

Markets, Notes and News.

The prices quoted herein relate to bulk quantities. Unless otherwise specified home trade quotations are delivered f.o.t. Export quotations are f.o.b. steamer. A comprehensive list of the prices of materials mentioned below will be found on the next page.

The Imports of Iron and Steel.

The Board of Trade Returns for June show the effect upon imports of iron and steel of the agreement made at the end of April between the British steel makers and the Continental Cartel, which limits the quantities to be brought into the country until August 7th. The total imports of iron and steel were 98,181 tons, compared with 86,430 tons in May and 98,002 tons a year ago. It is interesting to note that imports in June, 1933, the year which was taken as the basis for the agreement, were 69,019 tons. Imports of pig iron showed a slight rise to 8096 tons, compared with 6397 tons in May. Of this quantity India sent 6311 tons and Norway and Sweden 3147 tons. The quantity of billets, bloom, and slabs imported in June fell to 17,777 tons compared with 19,211 tons in May. Belgium sent 9369 tons, France 7288 tons, and Germany 976 tons. The imports of sheet bars showed a substantial increase in June to 10,154 tons, against 4820 tons in May, Belgium again being the largest supplier with 6940 tons, Luxemburg coming next with 2683 tons. The imports of girders, beams, joists, and pillars totalled 10,153 tons, compared with 7217 tons in May. Special interest attaches to the imports of hoop and strip, since it is known that difficulties have arisen in the negotiations regarding these materials. In June the imports reached 3827 tons, compared with 2790 tons in May, whilst in June, 1933, the figure was 3261 tons. Plates and sheets, not galvanised nor tinned, were imported to the extent of 3118 tons in June against 3410 tons in May. The imports of railway material showed little change, the figure for June being 1328 tons and for May 1096 tons. Belgium was by far the largest supplier during June with a grand total of 48,500 tons, France coming a long way behind with 13,627 tons. Luxemburg was third with 8720 tons, and Germany next with 5867 tons, whilst imports from Sweden reached 5391 tons. From British India the imports were 6311 tons, all pig iron, whilst from other British countries the total was 4744 tons, but details of the materials are not given.

A Decline in Exports.

The exports of iron and steel in June decreased appreciably from 213,886 tons in May to 195,130 tons, and were also less than the exports for June last year, which totalled 204,139 tons. The total was considerably higher, however, than in the corresponding month of 1933, when exports reached only 153,787 tons. Exports of pig iron in June fell to 10,559 tons from 16,690 tons. Exports of bars, rods, angles, and sections, which in May were 20,007 tons, amounted to 17,474 tons in June, British India taking the largest quantity of 3797 tons and South Africa coming next with 1475 tons. Girders, beams, joists, and pillars were exported to a total of 2072 tons in June, compared with 2814 tons in May, whilst the exports of hoop and strip dropped to 4302 tons, against 5272 tons in the previous month. The exports of plates and sheets not under ¼in. thick declined to 11,852 tons compared with 19,541 tons in May. The quantity of plates and sheets under ¼in. thick exported also decreased, from 18,154 tons in May to 11,722 tons in June, there being a notable decline in the tonnage sent to the Argentine, which in May was 9077 tons and in June 2960 tons. Exports to Canada, however, rose from 1924 tons to 2631 tons in June. The quantities of black sheets exported reached 3766 tons last month, but this also showed a decline from the May figure of 4353 tons. Exports of galvanised sheets decreased from 23,796 tons in May to 21,559 tons in June. An increase was registered in the exports of tin-plates, which in June were 29,586 tons, compared with 25,229 tons in the previous month. A decline took place in the exports of tubes, which dropped from 23,869 tons in May to 20,913 tons last month. A satisfactory rise, however, was registered in the exports of railway material. The tonnage for June was 18,747 tons, compared with 11,637 tons in the previous month. New steel rails exported in June reached 7476 tons and "wheels and axles complete" 6279 tons. Canada was the best customer of this country in June, taking 19,787 tons, South Africa coming next with 19,683 tons, and India third with 18,597 tons. Exports to Russia reached 10,741 tons, and to the Argentine 10,840 tons.

Pig Iron.

The most interesting event in the pig iron market during the past week was the increase in the quotations for hematite. Prices for both West and East Coast brands were raised by 2s. 6d. This increase in price had been expected for the past week or two, as it had been difficult to obtain certain brands. On the other hand, the two furnaces belonging to Gjers, Mills and Co., Ltd., are shortly to be put into operation and this should ease any tightness in the position. According to reports, producers were by no means unanimous as to the advisability of raising their quotations, and the advance does not apply to Middlesbrough, Durham, and Northumberland districts. In the Sheffield area the price for mixed numbers is £3 18s. for East Coast and £4 3s. 6d. for West Coast hematite. The home demand for hematite has been on a good scale for several months past and stocks in the makers' hands have been considerably reduced. Deliveries to consumers' works, particularly in the Sheffield and Midland area, have been particularly heavy during the past week or two. Business in foundry iron has been interrupted by the holiday conditions ruling in some of the industrial districts. Shipments from the North-East Coast works have been affected by the Scottish holidays, but deliveries to local consumers have been moderately good. Producers are in a comfortable position and have good order books, whilst there is little iron in stock. It is interesting to note that the ascertained price of No. 3 Cleveland pig iron for the three months ended June 30th was 59s. 1d. per ton, compared with 58s. 3d. per ton for the previous quarter. The advance has provided a small wage increase for workmen under the sliding scale and has definitely put the production of pig iron on a sound price basis. In the Midland district the business in foundry pig iron has been on the quiet side. Most of the consuming works have supplies to come against running contracts and there is a slow but gradual expansion in the requirements of the light castings industries. The engineering foundries also are showing a tendency to take more iron. In the Midlands the weak spot in the market is the poor demand for forge iron, but even in this department there are signs of a belated improvement. The Scottish production is maintained, but a certain amount will go into stock as the steel works and foundries in the Glasgow district have been closed down for the annual holidays. Deliveries, however, are being resumed to the Falkirk foundries and English iron is again coming into the district, the quotation for No. 3 Cleveland being 67s. 3d. f.o.t. Falkirk to 70s. 3d. f.o.t. Glasgow. Midland brands of foundry iron, however, are quoted at 1s. 3d. per ton less.

Iron and Steel Production.

According to the monthly statement of the British Iron and Steel Federation, the production of pig iron in June amounted to 529,300 tons, compared with 558,900 tons in May and 514,900 tons in June, 1934. The month's production included 106,000 tons of hematite, 295,300 tons of basic, 104,700 tons of foundry, and 10,000 tons of forge pig iron. The output of steel ingots and castings amounted to 770,000 tons in June, compared with 853,300 tons in May and 757,500 tons in June, 1934. The reduction in steel production in June is due to the Whitsuntide holidays and the shorter month. There were ninety-seven furnaces in blast at the end of June, one furnace having been blown out and one put into operation during the month. Although the report does not say so, the furnace put into commission was at Wm. Baird and Co's Gartsherrie Works, and the one blown out was at The Low Moor Iron Company, Ltd. The following table shows the average monthly production of pig iron and steel ingots and castings over a period of years and the output for the past four months :—

	Pig iron. Tons.	Steel. Tons.
1913—Monthly average	885,000	638,600
1920 " "	669,500	755,600
1929 " "	632,400	803,000
1932 " "	297,800	438,500
1933 " "	344,700	585,300
1934 " "	498,200	738,300
1935—March	554,200	841,900
April	526,300	808,700
May	558,900	853,300
June	529,300	770,000

The Midlands and South Wales.

The volume of business in finished iron and steel in the Midlands has declined somewhat this week, but not sufficiently to cause surprise. Buying lately has been exceptionally active for the time of year, but now that the holiday season has begun in earnest a quieter period must be anticipated. Expectations that the Continental steel makers will re-open their books for the British market may also have had an influence upon the position, since many large consumers of Continental material in the past have not yet become accustomed to the changed conditions. This applies particularly to the Midlands, which in pre-tariff days were the happy hunting grounds of sellers of Continental steel. Under these conditions the Birmingham quarterly meeting last week disclosed little change in the situation from that ruling for months past. The demand for structural steel is one of the features of the market and there seems to be little likelihood of requirements contracting, as constructional engineers are not only well employed, but have a considerable amount of fresh work in view. The mills producing light sections, however, are not so busy as those making the heavier sizes. There has been an active demand for small steel bars and the re-rolling works have little to complain of in the way new orders are coming to hand. During recent weeks there has been a tendency on the part of works outside the Association to increase their prices, and up to £7 17s. has been asked on occasion, although it is probable that a good order could be put through at £7 12s. 6d. to £7 15s., according to the tonnage. Associated works, however, hold their official price at £8 12s. less rebates of from 2s. 6d. to 5s. Little business has been transacted in heavy plates or boiler plates and some of the mills are anxious to obtain orders. Light plates are in better demand, whilst the sheet mills are moderately busy. The home demand for the latter description has declined somewhat ; but, on the other hand, some makers profess to see an improvement in the export trade in thin sheets. In South Wales the steel markets are showing more activity largely as a result of the slight improvement in trade which has been experienced by the tin-plate makers. There has been a fair demand for sheet and tin-plate bars and there seems to be no diminution in the volume of business in structural material.

Current Business.

The Newfoundland Government Railway has placed an order for two 3ft. 6in. gauge locomotives with the North British Locomotive Company, Ltd., Springburn, Glasgow. Hayward-Tyler and Co., Ltd., have obtained an order for forty-eight Duplex cargo oil pumps and 132 Duplex steam pumps for twelve tankers for the Anglo-Saxon Petroleum Company, Ltd. Smith's Dock Company, Ltd., of Middlesbrough, has secured an order for a small motor vessel. Thos. W. Ward, Ltd., of Sheffield, have received instructions from the group which is engaged upon a scheme for the reorganisation of the Jarrow Iron and Steel Works to demolish and dismantle redundant furnaces and other plant in preparation for the erection of modern units. The Midland Iron Foundry of Palmer's Hebburn Company, Ltd., Hebburn-on-Tyne, which was recently acquired by Vickers-Armstrongs, Ltd., is to be reopened in August. The Hebburn foundry of Vickers-Armstrongs, Ltd., is to concentrate on castings for the Elswick works. Following the launch of the cargo steamer "Inventor," the shipbuilding yard of D. and W. Henderson and Co., Ltd., of Meadowside, on the Clyde, has closed down as a shipbuilding establishment. In March last voluntary liquidation of the company was decided upon, but it was decided to finish the vessels remaining on the stocks. The Department of Overseas Trade reports that the following contracts are open for tender :—Egypt, State Domains Administration : Three tractors powered with engines of from 18 to 32 h.p., suitable for working on Mazout or Solar oil (Egypt, August 12th) ; Mechanical and Electrical Department, Ministry of Public Works, Cairo : Two pumping units with all accessories, to be of horizontal centrifugal type capable of discharging 150 litres of water per second against a manometric head of 5 m. and to be entirely driven by two 20 h.p. cold-starting, four-stroke Diesel engines, preferably of the vertical type (Egypt, August 5th) ; Ministry of Public Works : Supply, construction, and delivery of sewage purification works at Fayoum, and subsidiary works comprising three detritus and screening chambers with one inlet chamber, three sedimentation tanks, two sets of Sheffield aeration tanks with mechanical paddles, sludge pipes and beds, and distributing channels, dosing channels, four filter beds, night storage, and humus tanks and effluent and sludge pump house (Cairo, August 20th). South African Railways and Harbours : Steel tires and axles for 1936 requirements (South Africa, August 12th).

Copper and Tin.

The copper market seems to have quite recovered from the pessimistic mood of a week or two ago, and although it will take some time before confidence is fully restored, the tone of the market this week has been distinctly cheerful. Prices have shown an advancing tendency, and although buying has been rather spasmodic, there have been periods of considerable activity. Germany and Italy have both been in the market and in the United States consumers have bought on a heavy scale, one transaction involving 5000 tons having been reported. The countries which are the most anxious to buy copper are those which find it most difficult to purchase their full requirements, owing to exchange restrictions. This is particularly the case with Italy, and sellers to that country are acting cautiously, as in a number of cases old accounts have not been settled by firms which are eager to enter into new commitments. This week the copper producers have held meetings in London, but so far no announcement has been made with regard to policy. It is understood that the intention of the American as well as the South African and Belgian producers is to follow so far as possible the terms of the international arrangement. The market takes the view that the curtailment of production by at least 20 per cent. is necessary, and will automatically bring about an improvement in the copper position. There is little doubt that this programme is being adhered to, but the practicability of limiting American imports seems less obvious. The London standard market has stood up well against some rather heavy realisation, and it is probable that the bull account now has been reduced to comparatively small proportions. . . . No feature of note has developed in the tin market. The industrial demand from all quarters seems quiet, and American buying which at one time promised to develop on an active scale has again become indifferent, whilst the Continental demand is poor. The backwardation has again widened, and now stands at between £7 and £8. High premiums are asked for prompt parcels of Straits and Banca tin.

Lead and Spelter.

The situation in the lead market has not altered much over the past week or two, and on the whole may be considered decidedly satisfactory. The demand from the consuming industries is maintained and a certain amount of profit-taking by speculators has been well absorbed. The improvement in the requirements of the cable makers continues and there seems to be no decline in the quantities taken by the lead pipe and sheet manufacturers. The demand is, of course, almost entirely for Empire lead, and any of this material arriving is quickly taken up. In fact, it seems as though supplies are scarcely sufficient for the market, as in some cases consumers have to take bonded lead out of warehouses. The world's production of lead in May, according to American statistics, was 135,070 tons, compared with 128,366 tons in April. . . . Steady conditions have ruled in the spelter market. Whilst the demand from consumers has been maintained, most of them displayed an inclination to follow a cautious policy in making their purchases owing to uncertainty with regard to the revision of the duty. This, it is generally believed, has been decided upon by the authorities, but the market has no knowledge of when it will take place. The brass trades continue to take good quantities, but buying by the galvanisers has been lighter than usual. The position on the Continent seems to be improving, and satisfactory quantities are reported to be moving into consumption. Lately there has been an expansion in the demand for zinc sheets, and all the English mills are well employed. Additions to plant at the rolling mills are being made which, it is stated, will increase the total productive capacity of this country to over 30,000 tons per annum.

Current Prices for Metals and Fuels.

Makers' official home trade prices, per ton, delivered buyers' stations. Sections, joists and plates are subject to a rebate to home users purchasing only from associated British Steelmakers: joists, 22s. 6d.; plates and sections, 15s. Export orders of 250 tons and over may be subject to special quotations.

PIG IRON.

	Home.	Export.
	(*D/d Teesside Area*)	
N.E. COAST—	£ s. d.	£ s. d.
Hematite Mixed Nos.	3 11 6	3 2 0
No. 1	3 11 6	3 3 6
Cleveland—	(*D/d Teesside Area*)	
No. 1	3 10 0	3 4 0
No. 3 G.M.B.	3 7 6	3 1 6
No. 4 Forge	3 6 6	3 0 6
Basic (*Less 5/– rebate*)	3 10 0	—
MIDLANDS—		
Staffs.—	(*Delivered to Black Country Station*)	
North Staffs. Foundry	3 11 0	—
„ „ Forge	3 6 6	—
Basic (*Less 5/– rebate*)	3 15 0	—
Northampton—		
Foundry No. 3	3 7 6	—
Forge	3 2 6	—
Derbyshire—		
No. 3 Foundry	3 11 0	—
Forge	3 6 0	—
SCOTLAND—		
Hematite, f.o.t. furnaces	3 11 0	—
No. 1 Foundry, ditto	3 12 6	—
No. 3 Foundry, ditto	3 10 0	—
Basic, d/d (*Less 5/– rebate*)	3 10 0	—
N.W. COAST—		
Hematite Mixed Nos.	3 15 0 d/d Glasgow 3 18 6 „ Sheffield 4 7 0 „ Birmingham	

MANUFACTURED IRON.

	Home.	Export.
LANCS.—	£ s. d.	£ s. d.
Crown Bars	9 12 6	—
Best Bars	10 2 6	—
S. YORKS.—		
Crown Bars	9 12 6	—
Best Bars	10 2 6	—
MIDLANDS—		
Crown Bars	9 15 0	—
Marked Bars (Staffs.)	12 0 0	—
No. 3 quality	7 10 0	—
No. 4 „	8 0 0	—
SCOTLAND—		
Crown Bars	9 12 6	9 5 0
Best	10 2 6	9 15 0
N.E. COAST—		
Common Bars	9 12 6	8 15 0
Best Bars	10 2 6	9 15 0
Double Best Bars	10 12 6	10 0 0

STEEL.

LONDON AND THE SOUTH—	Home. £ s. d.	Export. £ s. d.
Angles	8 10 0	7 7 6
Tees	9 10 0	8 7 6
Joists	8 17 6	7 7 6
Channels	8 15 6	7 12 6
Rounds, 3in. and up	9 10 0	8 7 6
„ under 3in.	8 14 6	7 0 0
Flats, 5in. and under	8 14 6	7 0 0
Plates, ¼in. (basis)	9 0 0	7 15 0
„ 7/16in.	9 5 0	8 0 0
„ ½in.	9 10 0	8 5 0
„ 9/16in.	9 15 0	8 10 0
„ ⅝in.	9 10 0	8 5 0
NORTH-EAST COAST—	£ s. d.	£ s. d.
Angles	8 7 6	7 7 6
Tees	9 7 6	8 7 6
Joists	8 15 0	7 7 6
Channels	8 12 6	7 12 6
Rounds, 3in. and up	9 7 6	8 7 6
„ under 3in.	8 12 0	7 10 0
Plates, ¼in.	8 15 0	7 15 0
„ 7/16in.	9 0 0	8 0 0
„ ½in.	9 5 0	8 5 0
„ 9/16in.	9 10 0	8 10 0
„ ⅝in.	9 5 0	8 5 0
Boiler Plates, ¼in.	9 5 0	8 5 0
MIDLANDS, AND LEEDS AND DISTRICT—	£ s. d.	£ s. d.
Angles	8 7 6	7 7 6
Tees	9 7 6	8 7 6
Joists	8 15 0	7 7 6
Channels	8 12 6	7 12 6
Rounds, 3in. and up	9 7 6	8 7 6
„ under 3in.	8 12 0	7 10 0
Flats, 5in. and under	8 12 0	8 17 6
Plates, ¼in. (basis)	8 17 6	7 15 0
„ 7/16in.	9 2 6	8 0 0
„ ½in.	9 7 6	8 5 0
„ 9/16in.	9 12 6	8 10 0
„ ⅝in.	9 5 0	8 5 0
Boiler Plates, ¼in.	9 7 6 .. 7 15 0 to	8 5 0

STEEL (*continued*).

GLASGOW AND DISTRICT—	Home. £ s. d.	Export. £ s. d.
Angles	8 7 6	7 7 6
Tees	9 7 6	8 7 6
Joists	8 15 0	7 7 6
Channels	8 12 6	7 12 6
Rounds, 3in. and up	9 7 6	8 7 6
„ under 3in.	8 12 0	7 10 0
Flats, 5in. and under	8 12 0	8 17 6
Plates, ¼in. (basis)	8 15 0	7 15 0
„ 7/16in.	9 0 0	8 0 0
„ ½in.	9 5 0	8 5 0
„ 9/16in.	9 10 0	8 10 0
„ ⅝in.	9 5 0	8 5 0
Boiler Plates	8 12 0	8 17 6
SOUTH WALES AREA—	£ s. d.	£ s. d.
Angles	8 7 6	7 7 6
Tees	9 7 6	8 7 6
Joists	8 15 0	7 7 0
Channels	8 12 6	7 12 6
Rounds, 3in. and up	9 7 6	8 7 6
„ under 3in.	8 12 0	7 10 0
Flats, 5in. and under	8 12 0	8 17 6
Plates, ¼in. (basis)	8 17 6	7 15 0
„ 7/16in.	9 2 6	8 0 0
„ ½in.	9 7 6	8 5 0
„ 9/16in.	9 12 6	8 10 0
„ ⅝in.	9 10 0	8 5 0

IRELAND—	BELFAST. £ s. d.	REST OF IRELAND. £ s. d.
Angles	8 12 6	8 15 0
Tees	9 12 6	9 15 0
Joists	9 0 0	9 2 6
Channels	8 17 6	9 0 0
Rounds, 3in. and up	9 12 6	9 15 0
„ under 3in.	9 2 0	9 4 6
Plates, ¼in. (basis)	9 0 0	9 2 6
„ 7/16in.	9 5 0	9 7 6
„ ½in.	9 10 0	9 12 6
„ 9/16in.	9 15 0	9 17 6
„ ⅝in.	9 12 6	9 15 0

OTHER STEEL MATERIALS.

	Home. £ s. d.	Export. £ s. d.
Sheets.		
10-G. to 13-G., f.o.r.	9 10 0	8 15 0
14-G. to 20-G., d/d	10 15 0	9 0 0
21-G. to 24-G., d/d	11 0 0	9 5 0
25-G. to 27-G., d/d	11 12 6	9 17 6

The above home trade prices are for 4-ton lots and over; 2-ton to 4-ton lots, 10s. per ton extra; and under 2-ton lots, 30s. per ton extra.

Galvanised Corrugated Sheets, Basis 24-G.

Home.	£ s. d.
4-ton lots and up	13 0 0
2-ton to 4-ton lots	13 7 6
Under 2 tons	15 0 0

Export: £12 15s. 0d., c.i.f. India.
„ £11 5s. 0d., f.o.b. other markets.
„ Scandinavian Markets free.

Tin-plates.
20 by 14 basis, f.o.b. Bristol Channel Ports, 18/2.
Tin-plate Bars, d/d South Wales Works, £5 5s. 0d.

Billets.	£ s. d.
Basic (0·33% to 0·41% C.)	6 12 6
„ Medium (0·42% to 0·60% C.)	7 2 6
„ Hard (0·61% to 0·85% C.)	7 12 6
„ „ (0·86% to 0·99% C.)	8 2 6
„ „ (1% C. and up)	8 12 6
Soft (up to 0·25% C.), 500 tons and up	5 10 0
100 to 250 tons	5 17 6
Rails, Heavy, 500-ton lots, f.o.t.	8 10 0
„ Light, f.o.t.	7 10 0

FERRO ALLOYS.

	Per Ton.	Per Unit.
Tungsten Metal Powder	3/3 per lb.	
Ferro Tungsten	3/– per lb.	
Ferro Chrome, 4 p.c. to 6 p.c. carbon	£21 15 0	7/–
„ „ 6 p.c. to 8 p.c.	£21 10 0	7/–
„ „ 8 p.c. to 10 p.c.	£21 10 0	7/–
„ Specially Refined		
„ „ Max. 2 p.c. carbon	£34 0 0	11/–
„ „ „ 1 p.c. carbon	£36 5 0	11/–
„ „ „ 0·70 p.c. carbon	£37 5 0	12/–
„ „ „ carbon free	9¾d. per lb.	
Metallic Chromium	2/5 per lb.	
Ferro Manganese (loose)	£10 15 0 home	
„ Silicon, 45 p.c. to 50 p.c.	£12 15 0 scale 5/– p.u.	
„ „ 75 p.c.	£17 17 6 scale 6/– p.u.	
„ Vanadium	12/8 per lb.	
„ Molybdenum	4/6 per lb.	
„ Titanium (carbon free)	9d. per lb.	
Nickel (per ton)	£200 to £205	
Cobalt	5/– to 5/6 per lb.	

NON-FERROUS METALS.

Official Prices, July 17th.

COPPER—		
Cash	£31 13 9 to £31 15 0	
Three months	£32 2 6 to £32 3 9	
Electrolytic	£35 5 0 to £35 10 0	
Best Selected Ingots, d/d Birmingham	£36 0 0	
Sheets, Hot Rolled	£62 0 0	
	Home.	Export.
Tubes, Solid Drawn (basis)	10d.	10d.
„ Brazed (basis)	10d.	10d.
BRASS—		
Ingots, 70/30, d/d Birmingham	£29 0 0 to £31 0 0	
	Home.	Export.
Tubes, Solid Drawn, 2/1 Alloy	9¼d.	9¼d.
„ Brazed	11¼d.	11¼d.
TIN—		
Cash	£232 15 0 to £233 0 0	
Three months	£224 10 0 to £224 15 0	
LEAD	£14 7 6 to £14 8 9	
SPELTER	£13 16 3 to £14 0 0	
Aluminium Ingots (British)	£100	

FUELS.

SCOTLAND.

	Export.
LANARKSHIRE—	
(f.o.b. Grangemouth)—Navigation Unscreened	13/– to 13/6
„ Glasgow—Ell	14/6
„ „ Splint	17/–
AYRSHIRE—	
(f.o.b. Ports)—Steam	13/– to 13/6
FIFESHIRE—	
(f.o.b. Methil or Burntisland)—	
Prime Steam	13/6 to 14/–
Unscreened Navigation	13/– to 13/6
LOTHIANS—	
(f.o.b. Leith)—Hartley Prime	12/6 to 13/–
Secondary Steam	11/9 to 12/–

ENGLAND.

YORKSHIRE, MANCHESTER—	
B.S.Y. Hard Steams	18/6 to 21/6
Furnace Coke	15/– to 16/–
NORTHUMBERLAND, NEWCASTLE—	
Blyth Best	14/– to 14/6
„ Second	13/3 to 13/6
„ Best Small	10/6 to 11/–
Unscreened	12/6 to 13/6
DURHAM—	
Best Gas	14/8
Foundry Coke	19/– to 20/–

SHEFFIELD—	Inland.
Best Hand-picked Branch	23/– to 25/–
South Yorkshire Best	20/– to 22/–
South Yorkshire Seconds	17/– to 18/6
Rough Slacks	8/– to 9/–
Nutty Slacks	7/– to 8/6

SOUTH WALES.

CARDIFF—	
Steam Coals:	
Best Admiralty Large	19/6
Seconds	19/– to 19/4½
Best Dry Large	18/9 to 19/3
Ordinaries	18/3 to 18/6
Best Bunker Smalls	12/6 to 13/6
Cargo Smalls	11/6 to 12/6
Dry Nuts	22/– to 26/–
Foundry Coke	27/– to 40/–
Furnace Coke	19/– to 22/6
Patent Fuel	21/–
SWANSEA—	
Anthracite Coals:	
Best Large	36/– to 40/–
Machine-made Cobbles	41/– to 48/6
Nuts	40/– to 48/6
Beans	25/– to 30/–
Peas	19/– to 23/–
Rubbly Culm	11/6 to 12/–
Steam Coals:	
Large Ordinary	18/– to 20/6

FUEL OIL.

Inland consumption; contracts in bulk.
Exclusive of Government tax of 1d. per gallon.

Ex Ocean Installation.	Per Gallon.
Furnace Oil (0·950 gravity)	3½d.
Diesel Oil	4d.

French Engineering Notes.

(From our own Correspondent in Paris.)

Railway Organisation.

AFTER examining possible methods of meeting the railway deficit, the Budget Commission appointed to deal with the matter has decided that nothing can be done by "patching up leaks," and that the only solution is an entire reorganisation of the transport systems, so that, while no further losses will be incurred by the railways, the huge deficit that has accumulated during the past five years may be absorbed in time. The Commission will therefore prepare a plan to be presented to Parliament when it reassembles. The heavy railway losses are attributed to the onerous obligations that were imposed upon the companies more than sixty years ago, as well as to their complete subjection to Parliament, which rendered inoperative the Convention of 1921 giving to the companies a certain measure of liberty that would probably have averted the present financial disaster. The Commission intends to put an end to this state of things by preparing a plan that will cover all transport systems by rail, road, air, and water, so that they can all be assured of a legitimate share of the traffic without unreasonable competition. Railway lines that are run at a loss and cannot be made to pay by the substitution of railcars for steam locomotives or by other means will be suppressed, and the companies will be allowed to organise their systems in a manner to adapt them to modern traffic conditions. In coming to this decision the Commission is merely giving effect to plans that have long been under discussion and are being put into partial practice in a fragmentary manner that deprives the companies of any chance of escaping from their financial difficulties. In ordinary circumstances the new plan would meet with strong opposition from private interests represented in the Chamber of Deputies, and it is probable that Government will make a liberal use of decrees during the period of its investiture with full powers, so that when Parliament assembles the Bill will confirm a state of things already existing.

Goods Traffic.

One of the first decrees issued relates to the immediate carrying out of the plan to co-ordinate road and rail traffic so far as the carriage and distribution of goods are concerned. It must be completed by the end of the year. It is part of the general plan already having force of law, which provides that railway companies will arrange with road hauliers in each Department to work in collaboration with them under certain specified conditions. Those arrangements are entered into under the direction of a Departmental Technical Committee and are submitted for final approval to the Committee of Co-ordination at the Ministry of Public Works. A list of all road hauliers engaged in the public transport of goods must be supplied to the Government Commission, and provisional licences, involving the payment of fees, will be granted to those operating within the railway distributing areas. The railway companies will supply full particulars of the manner in which goods are handled on lines over which they are carried and information concerning lines that only deal with goods occasionally, or do not carry them at all. When all these data have been collected the Government Commission will complete its plan for the distribution of goods traffic, when the railway companies will be given preference for the traffic they can handle under the most favourable conditions, and road hauliers will work in conjunction with the railways, or may be given independent concessions in cases where they can render special services to the public.

Civil Aviation.

Since General Denain became Air Minister there has been marked progress in military and naval aviation, as well as in civil aviation, represented by the Compagnie Air-France, in which the State is directly interested. Civil air organisation owes much to the initiative and guidance of the Minister, who introduced methods that have given cohesion to all branches of the air services. The reorganisation of the aircraft industry, the selection of types of machines incorporating the best in home and foreign technical progress, and a certain standardisation in construction, have enabled civil aviation to make a practical start with commercial flying services that for several years had been attempted with disappointing results. Last week, a national service, known as Air-Bleu, was inaugurated with four postal lines from Paris to Lille, Havre, Strasbourg, and Bordeaux. Caudron machines are used with Renault engines of 180 h.p. driving variable-pitch propellers. The machines travel at a commercial speed of 160 m.p.h. The whole of French North Africa is being linked up with frequent air services, and the complete flight to South America is now undertaken twice a month each way, intermediate services being continued across the South Atlantic by naval scouts until such time as they can be replaced by new ocean flying machines. The French are so far satisfied with the ability of their new big aircraft to cross the Atlantic with safety that they are pushing on with arrangements to start a service between Lisbon and New York by way of the Azores. Negotiations do not appear to have been carried far with the Portuguese Government, but a Portuguese Aviation Company has been formed at Lisbon with French interests with a view to obtaining a concession for the line to the United States, which would necessarily have to be run under the Portuguese flag.

Shipping.

The activity of German shipowners in having fast ships built for service to the Far East has awakened French owners to the necessity of modernising their fleets, and the successful results obtained by the Messageries Maritimes with two ships that were lengthened and increased in engine power have induced them to put two other ships in hand to be transformed in the same way. Builders are making the most of this necessity to keep pace with competition at a time when speed and fuel economy are regarded as primary factors in securing freights under profitable conditions.

British Patent Specifications.

When an invention is communicated from abroad the name and address of the communicator are printed in italics.

When an abridgment is not illustrated the Specification is without drawings.

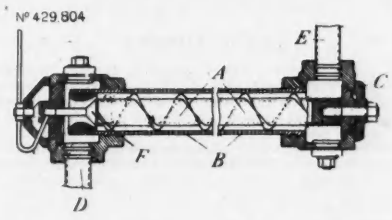
Copies of Specifications may be obtained at the Patent Office, Sale Branch, 25, Southampton-buildings, Chancery-lane, W.C., 1s. each.

The date first given is the date of application; the second date, at the end of the abridgment, is the date of the acceptance of the complete Specification.

STEAM GENERATORS.

429,804. April 11th, 1934.—WATER-TUBE BOILERS, Petr Dmitrevskij, Stresovická ul 598, Prague XVIII, Czechoslovakia, and Dimitrij Astrov, Wuchterlova ul 584, Prague XIX, Czechoslovakia.

A core A, with a helical fin, is arranged inside the water tube B and is fixed in the header C. At the opposite end it is free to slide endways. Water is forced into the tube at D and the

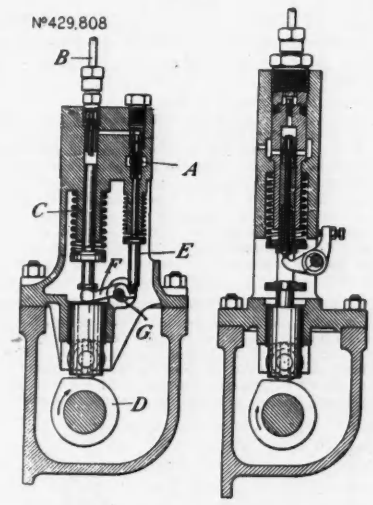


steam taken away at E. The centrifugal force produced by the helix is so great that the water presses against the inner surface of the tube with so great a pressure that steam cannot be generated there. There is always solid water on the heating surface, and, as a consequence, the inventors claim, scale cannot form. The rate of flow through the tube is controlled by the relative expansion of the two tubes and the valve-like arrangement F.—*June 6th*, 1935.

INTERNAL COMBUSTION ENGINES.

429,808. June 4th, 1934.—FUEL INJECTION PUMPS, Sulzer Frères Société Anonyme, Winterthur, Switzerland.

This is a fuel pump for reversible solid injection engines. The fuel suction is shown at A and the delivery at B. Both are controlled by non-return valves. The working plunger C of the pump is operated by a quick-action cam D, which terminates the stroke of the pump at the end of the compression

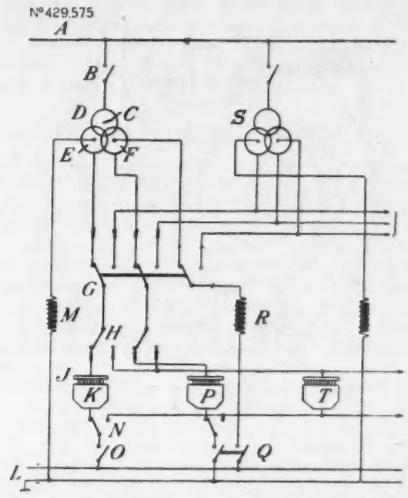


stroke of the main piston. Beneath the suction valve there is a tappet E, which is operated by the lever F. The pivot G of this lever is on an excentric which is connected with the governor, so that the valve may be held open appropriately, according to the load and the direction of turning of the engine. The fuel injection, however, always finishes at the end of the stroke.—*June 6th*, 1935.

TRANSFORMERS AND CONVERTERS.

429,575. January 28th, 1935.—RECTIFIER OR CONVERTER SYSTEMS, The British Thomson-Houston Company, Ltd., Crown House, Aldwych, London, W.C.2.

This arrangement is intended to avoid large numbers of automatic switching operations where a railway system is supplied with direct current from an alternating source, and it is desired to adopt regenerative braking. A three-phase network A is connected through a load switch B with the primary winding C of a transformer D, which is equipped with two separate secondary windings E and F. The winding F is connected through change-over switches G and H when they are in the position indicated, and through a current divider J with the anodes of a discharge vessel K, which need only be arranged for rectifier operation. The rectifier formed by the transformer D and the vessel J delivers energy to a direct-current network L through the choke M and the change-over switch N (indicated position) and through the quick-acting switch O. If, conversely, energy is to flow from the direct-current network into the three-phase current network, then without any change-over a discharge vessel P, which is already prepared for operation, comes into operation and which only need be set up as regards its control arrangement for inverter operation and which can deliver energy to the three-phase current network through the winding F of transformer D set up for a higher anode voltage corresponding to the inverter operation. The flow of energy then takes place from the direct-current network through the quick-acting switch Q and the choke R and the vessel P and the associated change-over switches to the three-phase network. The transformer S, serving as reserve as well as the reserve vessel T, are actually ready for operation, but not connected, and, in consequence, require no no-load energy if no account is taken of the energy for the vacuum pump. For the case when the inverter vessel P fails, its change-over switches are changed over without voltage. After the reinsertion of the switches B and Q, the vessel T takes over the function of the inverter. If, on the other hand, the vessel K cannot be operated, then the switches H and N must be changed over so that the vessel T may take over the rectifier operation. Since, in the case of the connections mentioned, the reserve vessel T is connected to the appropriate winding of the transformer D, no special measures need be taken at the vessel T apart from the control arrangement having to be adjusted for the operation actually required before the vessel is inserted—

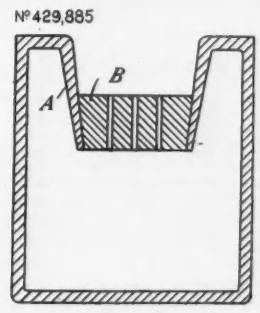


that is to say, that with the change-over arrangements in the main current circuit the corresponding change-over arrangements in the control circuits are to be actuated so that the vessel actually to be put into operation with the applying of the anode voltage must be controlled in the correct manner according to the desired direction of energy. The change-over switches G coupled with one another, provided in the arrangement in case of failure of the rectifier transformer D, allow of the insertion of a reserve transformer S of the same design.—*May 31st*, 1935.

BATTERIES AND ACCUMULATORS.

429,885. December 6th, 1934.—CONTAINERS FOR STORAGE BATTERIES, K. A. Hillyers, 14, Ivy-road, London, N.W.2.

This is virtually an adaptation of the old familiar "drunkard's inkwell" to accumulator construction. The cover of the case has a depending portion A in which there is a "cork" B per-

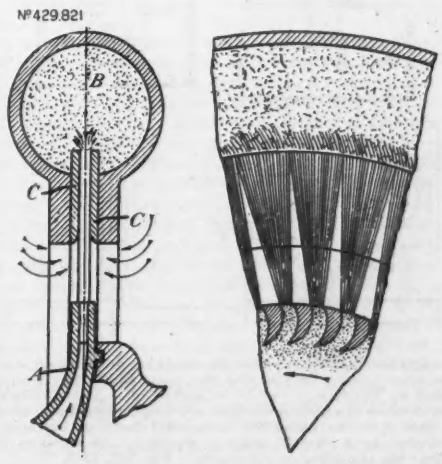


forated for the connections to the plates and for the egress of gas. The level of the liquid is kept below the bottom of the cork, and the enclosed space above that level is sufficient to contain the liquid, so that it will not be spilled on overturning.—*June 7th*, 1935.

PUMPING AND BLOWING MACHINERY.

429,821. January 22nd, 1935.—AIR EJECTOR PUMPS, Kingsford Industrial and Trading Company, Ltd., 61, Moorgate, London, E.C.2, and P. C. Lemale, 7, Rue d'Argenteuil, Paris, France.

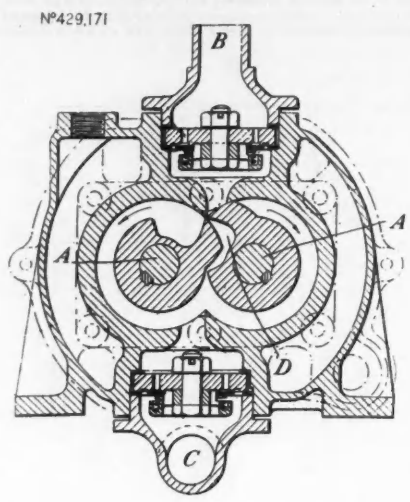
This pump is of the type in which jets of water from a centrifugal impeller are used to entrain and eject the air or other gas.



The illustrations reproduced show a portion of the impeller A and the collecting volute B. The impeller is made in two pieces, so that all its faces can be machined and projects jets of water so parallel, sideways, that they pass between the ejector plates C C without friction. The jets are also so shaped circumferentially that they converge at the outer edge of the plates and prevent a reflux of atmospheric pressure.—*June 6th*, 1935.

429,171. September 29th, 1933.—Rotary Compressors, A. J. Northey, Rilston, Springfield-road, Parkstone, Dorset.

This rotary compressor is more or less of a familiar generic type, but is claimed to have an unusually high efficiency. The two rotors A A are geared together and have blades which

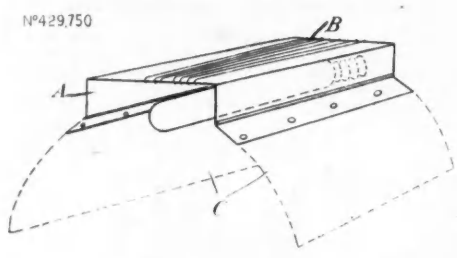


effect the compression action between the inlet B and the delivery C. It is claimed that the air, for instance, entrapped in the space D after the blades have passed the delivery opening, re-expands and "supercharges" during the next revolution.—*May 27th*, 1935.

LIGHTING AND HEATING.

429,750. October 6th, 1933.—Electric Lamps, The British Thomson-Houston Company, Ltd., Crown House, Aldwych, London, W.C.2, L. J. Davies, 147, Murray-road, Rugby, C. Gibson, 46, South-street, Rugby, and W. J. Scott, 16, Oval-road, Rugby.

The inventors explain that it is not generally possible to operate high-pressure vapour discharge lamps, except in a vertical

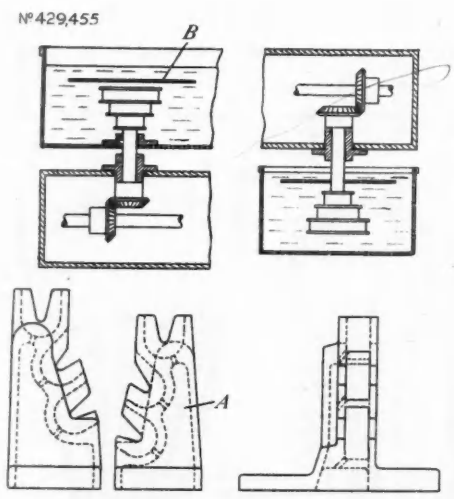


position, as the arc may be deflected by internal convection currents and touch the lamp tube, which may then be fused. In order to permit operation in a horizontal position, they arrange a screen A of magnetic material over the lamp and provide it with an energising winding B. The remainder of the shade C is of non-magnetic material. In this way the arc is stabilised in the centre of the tube.—*June 6th*, 1935.

MACHINE TOOLS AND SHOP APPLIANCES.

429,455. August 15th, 1934.—Wire-Drawing Machines, W. Nacken, 38, Chemnitzer Strasse, Grüna, Saxony, Germany.

This invention is chiefly concerned with the supply of lubricant to the dies of continuous wet drawing machines. The dies and drums are immersed in a bath of the lubricant. The dies are held in brackets A, which are hollow and provided with

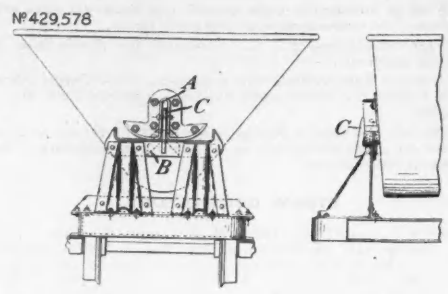


passages through which jets of the liquid are projected on to the dies by a pump. In this way any slime which may tend to collect on the face of the die is washed off. As the drawing drums rotate at a high speed, there is a tendency for the lubricant to form a vortex round the drum and starve it, but this is prevented by a plate B, which is hinged to give access to the drum when threading up a new wire.—*May 30th*, 1935.

TRAMWAYS AND RAILWAYS.

429,578. February 21st, 1935.—Railway Tip Wagons, W. S. Hudson and P. Hudson, Raletrux House, Meadow-lane, Leeds.

In this tip wagon the pivot is formed by a piece of angle iron A bent to the form shown. Tipping results in the horn-shaped parts rolling on the track bar B, which is also of angle iron. A catch C is pivoted between the two upstanding parts of the pivot and catches under the track bar to prevent tipping. The

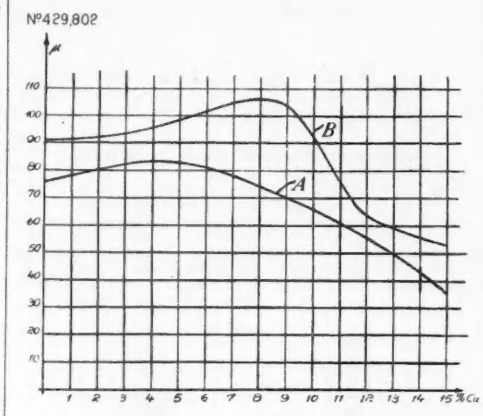


upper part of the catch can be wedged against the end of the wagon to hold it open while tipping is taking place.—*May 31st*, 1935.

METALLURGY.

429,802. March 29th, 1934.—Magnetic Cores, Siemens and Halske Aktiengesellschaft, Berlin-Siemensstadt, Germany.

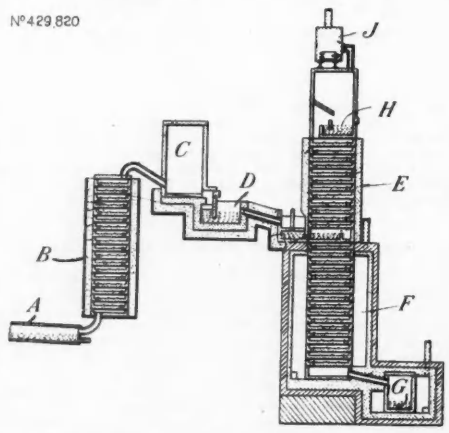
This invention relates to magnetisable elements such as those for Pupin coils, and suggests an alloy of iron with 35 per cent. nickel and 9 per cent. copper. This alloy is reduced to the required thinness by a cold rolling process described in the specification as follows:—The manufacture of magnetisable elements such as cores and the like, for electrical purposes, from wires or ribbons of a magnetisable metal, produced by reducing the metal in cross section by hammering or section rolling with stressing of the metal on all sides in at least the last stages of



such reduction prior to the stage of flat rolling into ribbon form in the case of ribbons, and up to the final condition for use in the case of wires which are not of ribbon form, the said reduction being effected with the metal in the cold condition without any heat treatment in and after the said stages of the reducing operations. The graph in which permeability is plotted in dependence upon the Cu content of the alloy shows that the material worked by the section rolls as depicted by curve B attains a considerably higher initial permeability than the material rolled directly down to a ribbon as depicted by curve A.—*June 6th*, 1935.

429,820. December 28th, 1934.—Purifying Zinc, Improved Metallurgy, Ltd., 95, Gresham-street, London, E.C.2.

This invention is concerned with the refining of zinc metal containing lead, cadmium, and other impurities. The metal is volatilised in the retort A, and the vapour passed to the rectifying column B, which is composed of a series of refractory trays that hold shallow pools of the condensed metal vapour.



The zinc vapour ascends to the condenser C, while the liquid lead flows back to the retort, whence it is occasionally decanted. The liquid metal from the condenser C flows through the trap D to the cadmium-eliminating column E. This column is very similar to the lead rectifier column, but is heated in the lower part by the furnace F. The pure zinc is tapped off at G, while cadmium-rich zinc condenses at H, and any dust is collected in the canister J.—*June 6th*, 1935.

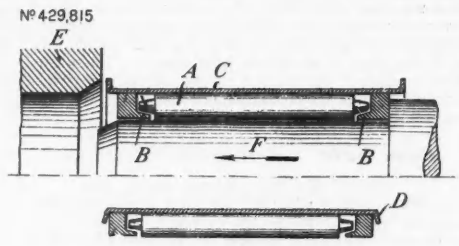
MISCELLANEOUS.

429,763. December 6th, 1933.—Fuel Oil, E. I. Du Pont de Nemours and Co., Wilmington, Delaware, United States of America.

This invention relates to fuel oil and to primers therefor, which are added to the fuel oil for the purpose of lowering its spontaneous ignition temperature and/or accelerating its combustion. Fuel oil containing such primers finds its chief use in connection with the internal combustion engines of the Diesel type. The beneficial action of such primers in shortening the delay period between injection of the fuel oil and its ignition, and in eliminating bumping, has already been pointed out by previous workers. The inventors have found that excellent primers for fuel oil are provided by non-aromatic organic compounds containing an oxime group (=N O H). These substances may be added to the oil in various concentrations, ranging up to about 10 per cent. as a maximum, but preferably small amounts of the order of 1–5 per cent. are used. The substances must be non-explosives and soluble in the oil in the extent to which they are employed. Examples of suitable primers in accordance with the invention are as follows:—Formaldoxime, acetaldoxime, butyraldoxime, isobutyraldoxime, heptaldoxime, acroleinoxime, acetoxime methyl ethyl ketoxime (2, 2'-dimethyl butanoxime-3), methyl hexyl ketoxime, methyl isopropyl ketoxime, cyclohexanoneoxime, cyclopentanoneoxime, 1-methyl cyclopentanoneoxime, cycloheptanoneoxime, glyoxime, methyl glyoxime, dimethyl glyoxime, propandione—1 : 3 dioxime and pentandione—1 : 3 dioxime. These primers are non-explosive and do not give rise to undesirable decomposition at ordinary temperatures. They are also relatively non-volatile and, consequently, have little or no tendency to escape from solution in the oil. The nature of the improvement effected by the addition of the primers to fuel oil is illustrated by the following tests. A fuel oil was tested in a Moore apparatus and found to have a spontaneous ignition temperature of 500 deg. Cent. The delay period between injection and ignition, at a temperature of 514 deg. Cent. and 0·94 seconds. By adding 5 per cent. of n-butyraldoxime or n-heptaldoxime to the oil, the spontaneous ignition temperature was reduced to 325 deg. and 350 deg. Cent. respectively, the corresponding delay periods at 514 deg. Cent. being 0·57 and 0·59 seconds. The same fuel oil, when saturated with cyclohexanoneoxime, or dimethylglyoxime, showed delay periods at 514 deg. Cent., or 0·63 and 0·69 seconds respectively.—*June 6th*, 1935.

429,815. November 15th, 1934.—Needle or Roller Bearings, A. Pitner, and Société Anonyme des Roulements à Aiguilles, both of 34, Boulevard de l'Yser, Paris, Seine, France.

In order to facilitate the assembly of needle or roller bearings *in situ* the needles A are first assembled at the factory between



the end rings B B. These rings are held in place by the light metal temporary sheath C, which may be turned over, as shown at D, for the purpose of security. The needles are put in place in the bearing E by pushing them endways through the sheath by means of the shaft F.—*June 6th*, 1935.

THE I.E.E. OVERSEAS CONVERSAZIONE.

A conversazione of overseas members of the Institution of Electrical Engineers was held at the Institution's headquarters on Thursday, July 11th. After the reception by the President and Council, short addresses were delivered by Messrs. H. R. Harper and R. A. Watson Watt, who dealt with "Brown Coal Development in Victoria" and "The Cathode Ray Oscillograph" respectively. During the subsequent reunion in the library several demonstrations were given, including a repetition of the experiments illustrating Mr. Watson Watt's address, illustrating the principal properties of the cathode ray tube. Demonstrations by Mr. Clifford Patterson illustrated investigations on the economic production of effective street lighting and the effects that can be produced by discharge lamps. Mr. W. P. Digby showed a reflection meter which can be used to measure the tarnishing and corrosion of metals, variations in the content of sulphur, and certain other impurities in the atmosphere, and the fading of paints by ultra-violet light and immersion in fluids, &c. Mr. Patrick Hamilton gave a demonstration of a synchronous time system with automatic control for marine use. The attendance was considerably better than last year and, despite the extremely hot evening, the conversazione was a complete success.

CATALOGUES.

Heenan and Froude, Ltd., Worcester.—Publication No. 95/2 on car-testing equipment.

British Steelwork Association, Artillery House, Artillery-row, S.W.1.—A booklet entitled "Steel in Building."

Negretti and Zambra, 38, Holborn-viaduct, E.C.—List No. E/10 on electrical thermometers and pyrometers.

Stothert and Pitt, Ltd., Bath.—A loose-leaf publication dealing with steam and internal combustion engined cranes.

T. Chatwin and Co., Great Tindal-street, Birmingham 16.—A leaflet describing a new type of relieved die the firm is making.

Cochran and Co. (Annan), Ltd., 137, Victoria-street, S.W.1—Leaflet No. 53 on Cochran-Kirke exhaust gas "Sinuflo" boilers.

Sturtevant Engineering Company, Ltd., 147, Queen Victoria-street, E.C.4.—Publication No. 1135 on "Sturtevant Forges."

Renold and Coventry Chain Company, Ltd., Didsbury, Manchester.—Revised catalogue of chains for conveyors and elevators.

English Steel Corporation, Ltd., Vickers Works, Sheffield.—Summary of standard steels, Part III, "Steels for Special Purposes."

Gwynnes Pumps, Ltd., Hammersmith, W.6.—Catalogues No. 741, entitled "The Centrifugal Pump and its Application to Industry"; No. 743, an interesting description of a pumping plant installed at Fiskerton for drainage purposes.

Mr. Raymond Gill.—We have to record with regret that Mr. Raymond Gill, A.M. Inst. C.E., managing director, Raymond Gill and Co., Ltd., 92, Victoria-street, S.W., died suddenly on Thursday, July 4th. Mr. Gill was managing director of the company since its incorporation in 1933, prior to which he had carried on business in the name of Raymond Gill and Co. since November, 1923. For many years he had acted as London manager to Stothert and Pitt, Ltd., of Bath, and was widely known and respected in engineering circles.